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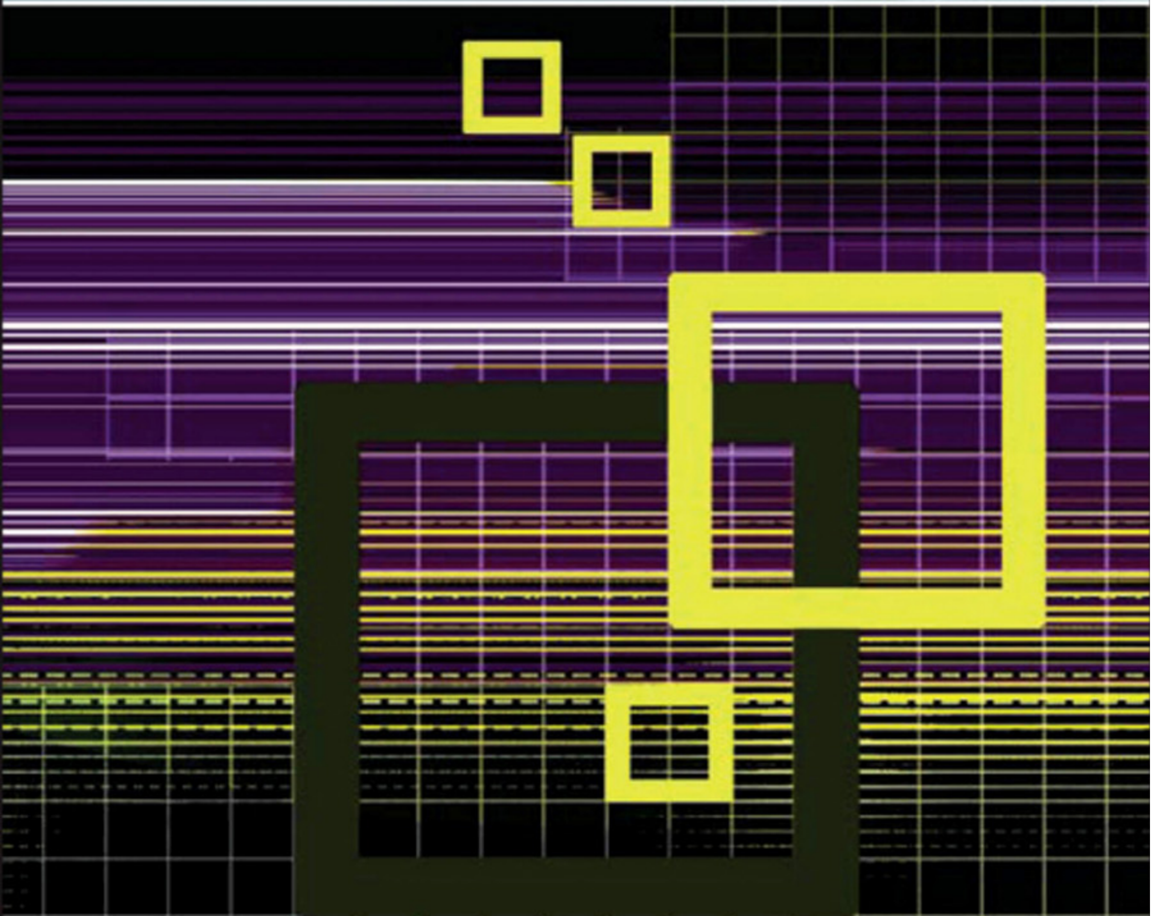

VERBAL MINDS

LANGUAGE AND THE ARCHITECTURE OF COGNITION

ANTONI GOMILA

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Language and the Architecture of Cognition

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1 Introduction: Language as the Key Factor to Human Singularity

The natural human interest in self-understanding has traditionally pointed to language as the most distinctive human trait. Many other features are also uniquely human. Some are anatomical: a big brain in proportion to the body, a lack of a tail, and a larynx with special phonetic capabilities. Some traits involve distinctive activities: religion, mathematics, art, and sport, for example. However, when it comes to making sense of human singularity, it seems that many of those specificities are not basic, but they became possible through achievement of more basic ones, such as language.

Of the several features uniquely human, then, language has been most consistently chosen as the key to understanding the human mind and to providing the building blocks necessary for achieving other specificities in human cognition: abstract/propositional thought, recursivity, decoupling of current situation, creativity, and conscious control (Chomsky, 1988; Macphail, 1996). To put it in some distinguished scholars' words: language is thought to be what makes us "smart" (Gentner, 2003; Spelke, 2003); or, at least, it is an important element of human intelligence, if not the only one (Premack, 2004). Maybe the influence of language depends in its turn on a more basic structural novelty that makes both human language and thought possible (Penn et al., 2007). Human cognition is characterized by its flexibility and creativity, which gives rise to, and is molded by, cultural diversity. Cultural diversity, in its turn, feeds back into cognitive diversity through the socialization process that takes place during the long period of human development. Language, as a symbolic system of communication and also of representation, is thought to play a critical role in making possible this interplay of individuality and sociality.

It is not so clear how language influences human cognition, however. The issue of the kind of role of language on human thinking—from which the cultural and behavioral novelties of human culture are thought to stem—is a polarizing one: while some people take it as obvious, others regard it as of marginal interest. For some thinkers, the constitutivists, the relationship is so intimate that thought is not even conceivable in nonlinguistic creatures: they view language as conceptually necessary for thought (Davidson, 1973, 1975; Dummett, 1981, 1989; McDowell, 1994). At the other extreme, the communicativists contend that language has nothing to do with thought whatsoever, beyond making it explicit (Fodor, 1975, 2008; Pinker, 1994, 2007). Of course, such extreme positions require a great deal of qualification. The first group is really only concerned with "propositional thought"—or the ability to entertain propositional contents—which is characterized by its truth conditions. Nonverbal creatures might be capable of simpler, referential thoughts, but given the conditions of content ascription, propositional thoughts are solely ascribable (by linguistic creatures) to linguistic creatures. The second group willingly accepts that language may

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be instrumental in the acquisition of many concepts, even most concepts (Devitt & Sterelny, 1987). Pinker, one of the spokesmen for this position, also concedes in passing that for one to be able to speak about reality, one needs to conceive of reality in terms of a particular language's requirements for communicating contents through one's speech (thus, languages differ in whether they require marking number, person, aspect, or voice) (Pinker, 1989, p. 360). They conceive of the main relationship between language and thought in the contrary direction, however: it is thought that conforms to language. Language is just the means for expressing thought, which is psychologically and semantically previous to language and is independent of how it is expressed. They adhere to a purely communicative view of language.

There has been a sort of pendulum dynamic in linguistics over the past 30 years or so. The communicative approach became hegemonic in the cognitive sciences in the eighties, but in the last decade there has been a lot of new evidence in support of the constitutivist approach. In 2011, it looks as though constitutivism is becoming mainstream. During the heyday of the communicative view (Gauker, 1992), the question of whether and how language might influence thought fell into disrepute. It was confronted with many central postulates of the cognitivist-computational approach that became dominant a strong nativism, an understanding of psychological processes as logical inference, a language-like view of mental representation, a modularist view of cognitive architecture, and an assumption of semantic–conceptual isomorphy. It became too difficult to fit linguistic effects on cognition into this general view of cognition, to the point that Pinker (1994) included a chapter with a necrological note on Whorf.

It is a well-known phenomenon in psychology, however, that the way in which a situation is linguistically described greatly influences whether it is attended, remembered, and valued. The effects of language on verbal tasks have been proven beyond doubt by the work of many, including that done by: Carmichael, Hogan and Walter (1932) on the effect of the lexical labeling of ambiguous pictures on memory; Glucksberg and Weisberg (1966) on problem solving; Loftus and Palmer (1974) and Schooler and Engstler-Schooler (1991) on explicit memory; Tversky and Kahneman (1981) and Kahneman and Tversky (1982) on the "framing effect" in decision making; Wickens (1972) on the influence of language on short-term memory; Barrett (2007) on emotion perception; and Styles (1994) on voluntary attention. How an experience is linguistically coded deeply influences how it is cognitively processed, and problem solving, in particular, benefits from linguistic formulation. The very diversity and sophistication of verbal tasks bear witness to the important role language plays in cognition.

The same realization can come from social life in: the feminist concern with sexist language; the diplomat's care with choice of words; the publicity and propaganda efforts of public figures; and the general tendency to use euphemisms. It is easy to find many examples of such behaviors showing that how we describe a situation in linguistic terms has powerful, cognitive effects that may also determine our emotional reactions and valuations. The following anecdote provides an example: one woman said to another: "Thank goodness for the word 'muffin.' Otherwise, I'd be eating cake for breakfast every morning." Similar effects of language have even led to some words being considered taboo and hence forbidden at times in history: advanced democratic societies and learned associations included (Chamizo, 2009). For a simple example: the British Sociological Association, in its "Guidelines for antisexist language" (April 2004), banned such words as "disseminate" and "seminal."

Of course, these examples amount to demonstrations of linguistic constitutivism. But they foster interest in the cognitive roles of language. After a period of disrepute, then, interest in the question of the relationship between language and thinking slowly returned, and it can be said that a cognitive view of language is currently fashionable, lively, and full of vitality. It is not easy to spot the stimulus, if there was one, of such intellectual changing of gears. Different disciplines have been involved: developmental, cultural, and comparative psychology; cognitive, linguistic, and evolutionary anthropology; cognitive linguistics; and philosophy of mind and language. Critical milestones in this resurgence were collective books such as: Gumperz and Levinson (1996) and Gentner and Goldin-Meadow (2000), which managed to put the discussion on firmer methodological ground and renewed theoretical approaches. The trend has given rise to a wealth of research in the last decade that deserves to be reviewed and synthesized, as we will try to do in this work. New approaches, new experimental paradigms, more stringent standards of evidence, and new ways to conceive of the relationship have been developed, so that it can be asserted that the debate has been moved to a new dimension.

Against the wealth of evidence that has been amassed in recent years, critics of the cognitive view of language tend to react in a paradoxical manner: they contend both that empirically demonstrated effects are trivial, and that they do not really support a cognitive role for language. If they were really trivial, then the shaping role of language would not even be up for discussion! But if they were really trivial, so much effort at experimental control to prove them would not have been required in the first place. In other words, a prerequisite to joining this debate is to show a proper respect for the empirical evidence, so painstakingly amassed. It required ingenuity in experimental design and the application of new statistical techniques, cross-cultural and comparative research, and long-term projects. If such a respect is achieved, the real issue, then, is one of superior explanation: which theory provides the best way to account for the empirical effects uncovered. It is then that the architecture of cognition occupies center stage: it is the source of explanatory concepts, basic processes, and levels of cognitive organization and mental representation. But there is not a single, universally agreed upon, cognitive architecture that can play a touchstone role. Thus, empirical evidence in this area—as in any other—can cast doubt on previous assumptions concerning cognitive architecture. Explanatory coherence requires a sort of cognitive equilibrium that pushes arguments both ways.

That coherence is why a proper account of the cognitive influence of language on human thinking also involves a discussion of cognitive architecture. In this regard, in the final chapter we will argue for a dual theory of thinking, as the best way to accommodate the evidence. This approach brings to the foreground the hypothesis that verbal minds are special because they are verbal, and that it is language that makes human cognition special: flexible, self-conscious, slow, and systematic. The "duality of mind" approach naturally accords with the idea that language has to do with what makes human minds dual in that way. Dual theories are committed to a view of "basic" cognition as independent of language, thus accounting for nonverbal thinking and for language acquisition processes, while being compatible with the hypothesis that higher order thinking comes about with language. I will propose a version consistent with an embodied cognitive science (Calvo & Gomila, 2008). The logical geography of cognitive explanation that it opens up, despite it coming short of forming a unified paradigm (Gomila & Calvo, 2008), provides for an easier accommodation of language as an organizational force of human cognition. In this work, however, I'll avoid direct discussion of the debate on the ground level of cognition. In particular, I'll take for granted that speaking of mental representations does not prejudge the outcome of this debate, assuming that postcognitivist cognitive science will also need to honor offline and internal state-mediated processes. I will argue, however, that a "language of thought," as the representational medium that is to account for the systematicity and productivity of higher cognition, is not basic, but parasitic on natural language (Gomila, 2008, 2010a).

Of course, there is also a trend that focuses on differences among human groups, and finds in language a crucial element for such differences, in the tradition associated with Whorf. While we will also pay attention to the cognitive effects of speaking one language versus speaking another, our emphasis will be on the effects of "being verbal" versus not being verbal as the crucial aspect to take into account for a proper understanding of the "verbal mind" and its architecture. Linguistic differences, while important, seem not to be as divisive a factor among human minds as nineteenth-century Romanticism claimed, in reaction to the Enlightenment's hierarchical views of human differences and Western supremacy. However, a lot of work has also focused on this dimension. I will follow Gentner & Goldin-Meadow's way of labeling these two areas of research: "language as lens", for the effects of speaking one language vs speaking another, and "language as tool kit", for the shaping effects of language on thinking (Gentner & Goldin-Meadow, 2003). The former approach looks for cognitive differences due to linguistic differences; the latter looks for cognitive surpluses made possible by language.

Our project, then, can be seen as "the case for a role of language in human cognition." Exactly which role will be proposed as a conclusion to our review, and it will depend on the reviewed evidence. The main dialectical rival, though, will be those views of human cognition that oppose the very possibility of such an influence and that tend to conceive of language as a sort of peripheral of the mind, as an extra "module" that we happen to have, without any remarkable consequence for the way the rest of alleged mental modules work. In its most extreme version, this view claims it is impossible for language to play any cognitive role: a bold contention that we will have to discuss from the start.

Our goal in this monograph, then, is triple-pronged: (a) to analyze the different ways the relationship between language and cognition has been conceived, (b) to review the evidence amassed in recent years on this relationship, and (c) to conclude which of the multiple ways to conceive of the relationship best accounts for the facts. I can already advance that it is not going to be an extreme or a radical conception, but that it will articulate how language makes possible some outstanding properties of human cognition. In addition, given the interdisciplinarity of the project, special attention will also be paid to methodological issues: the type of data required in these matters and how we can improve what we already have available.

2 Clearing the Ground

Before considering the relationship between language and thought, a preliminary dialectical move is required: calling into question the "in principle" arguments that foreclose the very possibility of a cognitive conception of language. Those arguments are grounded in a view of the architecture of the mind that conceives of language as a set of extra modules, added to an already modular cognitive system, working in a language-like representational medium, the "language of thought" (Fodor, 1975, 1983; Shallice, 1988; Smith & Tsimpli, 1995). There are two main versions of such an approach. The first is the "rational nativism" of Fodor, which proposes an innate language of thought and a cognitive architecture of input/output modules, plus a holistic central system for which a cognitivist–computational approach fails (Fodor, 2001a, 2008). The second is the "massive modularity" approach, which shares the computational view of mental processes, but hopes to block the holism of the central, cognitive ones, by splitting them into a series of computationally tractable cognitive modules (Barkow, Cosmides & Tooby, 1990; Carruthers, 2006; Pinker, 1997; Samuels, 2000; Sperber, 1996), at the cost of relaxing the notion of "module" to mean little more than a domain-specific system. Both camps agree that the conceptual primitives of the system cannot be learnt, but while Fodor argues that most concepts are primitive and hence innate (Fodor, 1975; 2008), Pinker believes that the primitive set is smaller and that most concepts are structured out of this set of primitives (Pinker, 2007).

According to this general approach, language is conceived as a "peripheral" to the mind, from which it is "decouplable." Its evolutionary emergence—according to this approach—has had no effect whatsoever on the rest of our cognitive abilities. Such an approach is committed to the view that our thoughts would be the same even if we were not linguistic beings. Language is just a means of expressing—of communicating—these language-independent thoughts. In Fodor's words: "English inherits its semantics from the contents of the beliefs, desires, intentions and so forth that it's used to express, as per Grice and its followers. Or, if you prefer (as I think, on balance, I do), English has no semantics" (Fodor, 1998, p. 13). Or in Jackendoff's words: "The terms semantic structure and conceptual structure denote the same level of representation" (Jackendoff, 1983, p. 24). The semantics of language is dependent on the conceptual contents specified by the language of thought, which it simply reflects.

This communicative view of language, however, turns out to be too simplistic when attention is paid to the cognitive requirements and effects of communication. Several well-known phenomena, such as: basic categorization, concept acquisition through language, conversational implicatures, mutual knowledge in pragmatic understanding, intentional attributions, and perceptual and memory effects of verbal

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descriptions, cast doubt on that assumption of conceptual-semantic isomorphy. The difficulties are made clearer when the question of the interface between thinking and language is raised. While expressions in natural languages depend on context to convey a proposition, and therefore not perfectly compositional, language of thought expressions are supposed to be perfectly compositional and context-free. The recognition of this pragmatic complexity creates difficulties for a language of thought view: it casts doubt on the main argument for the existence of a linguistic vehicle of internal representation, the supposed isomorphy between natural language sentences and propositional contents.

Such assumptions about cognitive architecture are then used in the service of arguments that seemingly make it "impossible" for language to have a shaping role in human thinking by means of a series of arguments that rely on these general assumptions. In this chapter, we will first call into question the communicative-expressive view of language and the idea of a language of thought as the vehicle for the contents for our thoughts. In the second section, we will review and discuss an anthological presentation of a number of arguments against the idea of influence of language on thought (Pinker, 1994). In the third one, we will discuss the massive modularity view of cognitive architecture. After this is done, a proper assessment of empirical evidence will be possible.

2.1 Against Language as a Peripheral to the Mind

A view in which language is a peripheral of the mind is one that restricts language to a purely communicative dimension, detached from the cognitive architecture of the mind. It holds an exclusively communicative view of language, as a set of mental modules that convert sound patterns into propositional contents, and the propositional contents of thought—the result of language-independent cognitive processes—into sound patterns. Linguistic modules, according to this generic view, are input–output modules, a sort of "peripherals" to the mind, decoupled from the workings of the latter. Thinking goes on quite independently of the linguistic processes—which are thought to be cognitively inert beyond their proper output—constituting a conceptual–pragmatic system. Fodor's proposal, in fact, views language an extra component of the mind, a set of modules that, in fact, expands its capabilities, but which does not modify the architecture of the system. Language is a group of components dedicated to delivering and parsing expressions of natural language (Chomsky, 1988; Levelt, 1989; Pinker, 1994), which may or may not get activated without further effects on other mental processes. In its turn, the massive modularity approach goes further by also deeming thinking to be carried out modularly.

This peripheral view of language was mainstream in cognitive psychology during the heyday of cognitivism: the doctrine that mental processes are computational processes that operate on propositional representations from a "language of thought," a symbolic, language-like medium of representation. Such a representational medium was thought to be previous to and independent of language, and is, in fact, the way to ground linguistic meaning: lexical terms get their meanings by getting associated with the corresponding mental symbol or concept. Concepts come first; language comes later and profits from this basic cognitive architecture. Given the coupling of the semantics of language to concepts, and the further belief that human conceptual structure has a universal, innate, common core across cultural differences it follows that semantic structure should also have a common universal core across cultures.

Is there any reason to accept such a view? There are two main arguments for this "language of thought" approach to thinking. The first is grounded in the isomorphy of the representational vehicles of thoughts with natural language: natural languages are systematic and productive, and these properties are due to the compositional semantics of language. Therefore, a language of thought, which also is thought to exhibit systematicity and compositionality, is supposed to require a corresponding compositional conceptual structure (Fodor, 1975, 1987, 2008). However, when the contextual dependency of natural language is taken into account (as exemplified by the general indexicality, polysemy, or ambiguity of sentences, among many other phenomena, all of which require a context to express a proposition), the argument becomes problematic because they show that the systematicity and productivity of natural language are not best explained by appeal to compositional semantics. So why should it be the case regarding the language of thought (Vicente & Martínez-Manrique, 2005)? Although Fodor himself has eventually acknowledged that natural language does not have compositional semantics (Fodor, 2001b), he doesn't seem to realize the further consequences of this fact with respect to his hypothesis of the language of thought. He still sticks to the logicist idea of a language of thought as the canonical way to express propositional contents, but this is an idea related to Fregean semantics, rather than to cognitive architecture. As we'll be discussing with respect to Pinker's argument, there is no contradiction in the idea of a "psychopragmatics": in the possibility of the context-dependency of mental representations (not to be confused with mental contents).

The second argument is that concept learning is impossible (Fodor, 1975, 1998, 2008), so the nonstructured conceptual units of the language of thought are considered to be innate. Given that concept learning is understood exclusively as hypothesis formation and testing, a large original conceptual repertoire is supposed to be available from the start to be able to form meaningful hypotheses in the first place. However, the well-established fact that the concepts one "activates" correspond to the meanings of one's language, entails that the language of thought will have to include all the possible "simple" concepts expressible in natural language meanings. Given that the criterion of "simplicity" is lexical, i.e., a concept is simple if it is lexicalized, if there is a simple word to express it, Fodor is committed to the idea that the language of thought will have to include as many concepts as there are different morphemes in any possible natural language (Fodor, 1998, p. 42, ft. 2). *A fortiori*, he is committed to the idea that the language one speaks is the best guide to which concepts, from all the innate possibilities, get activated: a view not that far from Whorf, himself, in the end.

In summary, then, Fodor's arguments for a language of thought are in trouble, and therefore are not enough to delegitimize the possibility that language plays a central role in shaping one's conceptual repertoire. In fact, the program is losing momentum in the cognitive sciences (Gomila, 2010a). Notice, in addition, that the very idea of a language of thought, distinct from natural language, does not entail a priority of thought over language, but for the logical argument that concepts cannot be learned. But if concepts are acquired through language use, then the language of thought could be conceived as derived from language, rather than the other way around. What's assumed is the communicative conception of language, which sees language as expression of thought. Fodor's language of thought, therefore, is just one way to develop this general, communicative, approach: not the only way. But the general view is also problematic. In particular, it is not obvious that every linguistic proference is preceded by a communicative intention that then transmits its content to the proference. Some linguistic proferences are automatic or institutionalized; in some cases, we don't know exactly what we want to say until we start speaking. We may also realize what we wanted to say after we spoke. In fact, most of speech is not intentionally prepared, but is rather nondeliberate and comes out of improvisation in context.

These intuitive cases cast doubt on a very general picture of linguistic communication as the means by which speakers convey the contents of their thoughts to their audiences. This is probably the deep assumption that drives the resistance to accepting the idea that language may play a cognitive role (Gauker, 1992). In the standard, Gricean articulation of this picture, one is supposed to start with a propositional content that is somehow linguistically coded to be transmitted. On the basis of those words, the audience is supposed to be able to realize that the speaker had the intention to transmit that propositional content. That is made possible by a common understanding of the linguistic code plus an intentional inference. But this is certainly a convoluted way of proceeding: the audience might just be in the business of grasping the meaning of the linguistic expression, rather than trying to get at thought content that the speaker is supposed to convey. Additionally, the speaker might be said to express a meaning by her choice of words, rather than expecting the audience to recognize her intention on the basis of understanding the meaning of the words said.

Grice utilizes this convoluted approach: to explain meaning in terms of intention and intention recognition (Grice, 1957, 1975). Grice's intentionalistic theory may be useful for rationally reconstructing meaning, but it over intellectualizes speaking. In practice, speaking is more similar to piano playing or skiing than to propositional problem solving: complex sequences of rule following intentional movements get activated in context, through practice, quite apart from strategic calculations or means-ends reasoning. Linguistic understanding is guided by contextual considerations, instead of intentional attributions (or what was meant by the speaker), with regard to scope of quantifiers, demonstrative reference, and proper names of reference. Critiques of Grice's theory point out that thought contents are acquired and explicated through mastering the use of words, which undermines the priority of thought over language. In particular, as it has been argued by social externalism about meaning (Burge, 1979), the contents of the thoughts depend on the linguistic practices of the linguistic community of the thinkers. Hence, thought content cannot be logically and psychologically prior to linguistic meanings, as the communicative view of language contends.

It is clear, then, that if one takes for granted such a view of linguistic communication, there is no room available to attribute a cognitive role to language. Unfortunately for such a view, as already remarked, there is no independent characterization of such thoughts, apart from their linguistic expression. Some other forms of thinking—such as visual or imagistic—are not equally shareable via communication, but they also do not easily fit into the language of thought representational vehicle either. Again, a more parsimonious explanation of the intimate relationship between language and propositional thought is that the latter somehow depends upon the former: the meaningfulness of thought is better understandable in terms of the meaningfulness of the words said.

2.2 Resisting "in Principle" Arguments Against the Influence of Language on Thought

In Chapter 3 of "The Language Instinct," (Pinker, 1994), Stephen Pinker brought together all of the arguments that have been put forward against the idea of the cognitive role of language (Fodor, 1975). Interestingly, his issue is with the idea that natural language is the medium of thought, which is only one of the ways to articulate a cognitive conception of language. It is not crystal clear that Whorf fully subscribed to the idea—although some textual evidence suggests that he did—nor is it clear that it is a necessary ingredient of linguistic relativism. If Pinker's arguments can be shown to be weak, despite being aimed at such an extreme version of the cognitive approach to language, the cognitive approach to language becomes a legitimate proposal. This is especially important, given that his arguments have been rehearsed later on—in one way or another—by other opponents to a cognitive role for language. Recently, in "The Stuff of Thought," Pinker (2007) again criticizes Whorfian relativism, but this time his target is solely linguistic determinism, and his tone is much less dismissive. Pinker claims the recent evidence (which we will be reviewing in the next two chapters) comes short of proving that the strongest version of linguistic determinism is true; he is not interested in distinguishing weaker versions, or other ways language has been shown to influence thinking. The reason, I submit, is because he is in the grip of the "language as peripheral," modularistic view, that we have just outlined. Once the shortcomings of such a view are made apparent, the ground is clear for a fair assessment of the evidence.

One of the central arguments against a cognitive conception of language concerns the possibility of nonlinguistic thinkers. Animals, as well as prelinguistic infants or nonlinguistic deaf people, can think, it is said; but they lack a natural language. Therefore, language is not required for thought. All that is required is a language of thought in which to think.

There are several aspects of this idea that deserve comment. On the one hand, the conclusion is a nonsequitur, unless it can be established that the thinking processes of such nonlinguistic creatures exhibit the same structural features of human propositional thinking. In other words: is it true that such creatures' thinking processes exhibit the same sort of systematicity and productivity as our own thinking processes are taken to exhibit? The problem is that all the examples of systematicy and productivity in thought turn out to be linguistic examples (Fodor, 1987). On the other hand, content attribution to nonverbal cognitive systems has been shown to be underdetermined, when it goes beyond imagistic, perceptually based contents (Bermúdez, 2003). Hence, it is simpler to conclude that these structural properties of human thinking are inherited from the recursivity and compositionality of language, which modify the basic cognitive architecture to make it conceptually discrete and propositionally structured. This distinction between two kinds of thinking is also coherent with dual theories of thinking, even those that apply to linguistic beings. This is not to say—as already remarked—that natural language is the representational medium of thought. It may well be the case that our systematic and productive language of thought, instead of being innate, is somehow derived from language acquisition, which thus transforms a simpler, iconic, or schematic representational ability.

This point, that humans thoughts are structurally different from non-verbal being's thoughts, is all that is needed to resist the battery of intuitive arguments Pinker enlists against the idea that we think in natural language:

a. the common experience of realizing that what we said doesn't express properly what we wanted to say;
b. the fact that we remember the gist of an idea, not the literal words with which we heard it expressed;
c. the possibility of new terms for new ideas;
d. the fact that language is learned; and
e. the fact that we can translate from one language to another.

All of the examples call into question the strict view that natural language is the medium of thinking, because all of them point out the possibility of distinguishing between the language level and the conceptual level: in expression and understanding, in lexical innovation, and in acquisition and translation. Therefore, Pinker concludes, thinking cannot be language-dependent. However, the correct conclusion that follows from these examples is that all thinking cannot be "completely" language-dependent, but neither case is enough to reject a partial influence. On the other hand, it is not a simple task to single out a type of thinking independently from language, as the arguments take for granted. In fact, it is also a common experience not to have a clear idea of what one wants to express before starting to express it: speaking helps clarify our thoughts. On the other hand, we'll review evidence on bilinguals holding language-relative semantics, rather than a unified conceptual level of representation: it could just be the case that two linguistically grounded ways of mental representation can be shifted and compared. The same idea applies to translation. Additionaly, the fact that language is learned does not exclude the possibility that—once learned—it can facilitate thinking processes. The possibility of the development of new terms does not prove that conceptualization has to be previous to labeling for everybody; on the contrary, novelty spreads in the linguistic community by getting the new concept from the linguistic meaning.

Again, it is the further assumption that language solely expresses thought that biases Pinker's discussion. In other words, all of these arguments do not prove that we think in an innate/modular language of thought (from here on, LOT). The arguments are perfectly compatible with the possibility that the conceptual level of thought is grounded in the semantic level of meaning, which is consistent with the linguistic acquisition of most concepts. This point may be made clearer considering an analogy. It is possible to put forward a Pinkerian argument by saying that an atlas cannot be our representational system for spatial positions, because we might misuse it, or because we might also use different projective systems, or because some feature in the atlas might be ambiguous or underspecified. It doesn't follow from this, as Pinker claims concerning language and the LOT, that our initial representation of space will share the same properties as those in an atlas (with proper meridians and parallels)—as Pinker's view requires the projection of the systematicity and productivity of language into the LOT—for it may well be the case that our initial system is simpler (egocentric, vector-based with the subject as center of reference) and that by learning to use an atlas we develop an allocentric understanding of space. Even if that were the case it would still be true that we don't think of space "in an atlas," but it would make sense to say that we have "internalized" the atlas form of spatial representation. Mutatis mutandis, we might think propositionally because we have internalized a linguistic means of conceptual representation.

Pinker also appeals to one of the classical arguments that pushed the view of language as expression of thought, originating in late nineteenth-century logicism. It posits that language "disguises" or "confounds" thought because its terms are ambiguous, inexplicit, polysemous, and vague, whereas thoughts—by definition—are taken to have perfectly determined contents, compositional semantics, and transparent coreferentiality, so that logical, truth-preserving relations can be defined over them. Such a view of the relationship between thought and language prompts another argument against the possibility that natural language has an influence on thought, derived from the fact that linguistic sentences require a pragmatic context to be able to express a determined content: the argument from underdetermination (Martinez & Vicente, 2005). We have already remarked on the difficulty this anisomorphy creates for the language of thought position. However, Pinker focuses on it to claim that natural language cannot be the medium of thinking, because it exhibits a series of features that amount to semantic underdetermination: ambiguity, lack of explicitness, referential opacity, deixis, and synonymy, while language of thought sentences are supposed to be perfectly determined (by its compositional semantics) and referentially transparent. These features are connected to the characteristic contribution of context in linguistic communication, which is assumed not to occur in thought, given the logicist Fregean conception of thought as propositional content. While Pinker's argument is cast on a Turing machine version of functionalism, the same point can be made in Fodorian language of thought terms (Fodor, 2001): the vehicle of thoughts need have only one definite content because they are not further interpreted.

Let's notice, to begin with, that such an argument is ironically grounded in the ambiguity of the word "thought." While Frege was clear that he was interested in thoughts as Platonic, abstract entities that can be shared by different thinkers, i.e., propositional contents with truth conditions, "thought" also means a component state of a thinking process (and in this sense, in particular, a particular element of the stream of thoughts of a particular thinker). There is not a clear reason, however, why a particular thought state must express a clear and perfectly determined thought, as propositional content. It is the latter that are supposed to be fully determined, from the logicist's point of view. In such a view, it is perfectly possible that a thinker may be unaware of the precise "thought as content" of her "thought as particular mental state," just as it is possible to hold vague, confused thoughts as opposed to "clear and distinct ideas" to put it in Cartesian terms. For this traditional notion of idea, the same duality exists between abstract content and mental particular (vd. Gomila, 1996). But once such meanings are distinguished, the argument fails because it relies on the equivocation between them. For it is simply not true that "thoughts as particulars" are always precisely determined; or in technical jargon: that they have definite truth conditions. The contents of the thoughts involved in our thinking processes may be as imprecise or ambiguous, and as contextually dependent, as our linguistic expressions can be. This is not surprising given that language is our canonical way to express our thoughts. Not even Frege expected the transparency of coreferential expressions in thoughts as abstract contents.

This means, therefore, that contents and vehicles are confused in the argument that claims that we don't think in natural language because its sentences are underdetermined while thoughts are not: thoughts as mental states can be as underdetermined as sentences; it is just thoughts as abstract contents that need to be determined. In other words, it is possible that a thought (particular mental state) does not expresses a thought (a fully determined content). There is no reason why thought vehicles must have fully explicit and determined contents, lacking deictical elements and synonymous expressions. As a matter of fact, the logicist project tried to regiment natural language through formal logic, as a way to make thought precise, a project which involved the rejection of psychologism, the grounding of content relationships on abstract contents, and the search for a "perfect language" of thought (similar in rigor and precision to that of mathematics). Pinker and company, in their turn, use this logicist argument within a psychological approach, within the computational theory of mind which does ground psychological contents on mental states, and conceives of thinking processes as the tokening of mental symbols and the logical inferences that follow. But it takes a great leap of faith to assume that such mental processes, even if conceived as computational ones, take place in a "perfect language" (Eco, 1990): one where representational vehicles somehow manage to reveal the structure of reality by capturing the metaphysical rock-bottom categories that constitute its joints.

The only reason for the idea of perfect determinacy and referential transparency of thoughts Pinker can offer comes from the Turing machine version of functionalism he spouses. In it, thinking processes are considered to be truth-preserving computational transformations of logical formulae. However, computationalism is just concerned with logical syntax, which operates on formal properties, regardless of content (which has to be independently interpreted, relative to an ontology); therefore, it comes short of establishing the full semantic determination of such formulae. Turing also considers that a system of communication must have different properties than a system of representation, but while this might be true from an optimal design point of view, it might not be true of evolutionary systems. For Pinker's argument to go through, he should show that there is a real gap between what can be said and what can be thought, and to do so noncircularly, rather than based on linguistic examples. The fact that thinking may be confused, context-dependent, and semantically underdetermined—just like language—actually supports the cognitive view of language. Pinker's arguments do not prove that we don't think in natural language. They prove, instead, that meaning is not just a matter of the activation of symbols in the head: a shared world of practices and common understanding is also required, as content externalism proposed.

2.3 Against Massive Modularity

The nativist/massive modularity view of cognitive architecture, which represents a roadblock for a cognitive conception of language, is deeply problematic in its own right quite apart from this issue. In this section, I will consider only one critical strand: its misconception of individual development as the simple turning on of innately specified modular systems. Such a view makes little ontogenetic sense. In particular, it ignores the social and cultural context in which such development takes place, and how it has an impact on the configuration of the individual mind. Another critical strand concerns its clumsy proposal of a module for metarepresentation (Cosmides & Tooby, 2000; Sperber, 2000), which will be considered in the final chapter in the context of the discussion of the link between language, cognitive flexibility and metarepresentation.

Modularist evolutionary psychology conceives of the human mind as a complex but fixed set of special-purpose mechanisms, each adapted to some specific function. In other words, from this standpoint the human mind is a set of evolutionary adaptations, a view whose emblematic metaphor is the Swiss army knife; but they are adaptations to the ancient environment of the Pleistocene, when *Homo sapiens* appeared in evolution. Among other elements of this peculiar, complex instrument, the following adaptations have been hypothesized: color perception, grammar, pregnancy sickness, jealousy, cheater detection, sex differences in spatial skills, esthetic appreciation of landscape, sex differences in mating preferences, and styles of parenting (Barkow, Cosmides & Tooby, 1990; Pinker, 1997).

This brand of evolutionary psychology thus opposes the idea of the autonomy of culture: the idea that evolutionary theory has nothing to contribute to the understanding of human culture. On the contrary, it is the psychological mechanism that modularist evolutionary psychology postulates that are supposed to generate some of the distinctive cultural features of human societies. The process is not deterministic, but interactive, such that the particular environment may modulate the expression of this universal set of mental modules. Historical change processes may also give rise to diversity. But these psychological mechanisms constrain the domain of possible cultures, and thus they set bounds to cultural diversity.

According to evolutionary psychology, it is psychological mechanisms involved in the production of behaviors, which can be selected for. Our behavioral repertoires are not bunches of standardized and ritualized behaviors, which could be taken out or replaced without disrupting others. Our behavior, on the contrary, is the result of complex interactions of distinct psychological mechanisms, each of them the groundwork of natural selection. Moreover, in evolutionary psychology it is wrong to think, as sociobiologists did, that contemporary human behaviors are adaptive, because it is to the ancestral environment of the Pleistocene that the human mind adapted when our species emerged as a hunter-gatherer species inhabiting the African savannah. In other words, were we to travel backward in space time—as in a science-fiction story—to a Pleistocene Stone Age human population, we would be perfectly adapted to survive and prosper there. Taken together, both points lead evolutionary psychologists to establish the following method of research:

1. Think of the environmental conditions during the Pleistocene Age, and try to discover which adaptive problems had to be solved by the new human beings in order to increase their fitness as they did and which selective pressures had to be faced by the human minds of the time.
2. Catalog the specific information that must be obtained, processed, and exploited to solve those problems. This step involves developing a computational theory of the task, and of the design features that any system must have if it is to implement the computational theory. For example, living in a semi-arid environment makes extremely valuable information about underground water flow. Let's suppose that we discover that the latter correlates with a deeper sand color; then it should be expected that such dim changes in color will be detectable, and that any system capable of detecting them will have some sort of colour sensitivity through luminic transduction.
3. Hypothesize a particular module—an innate, domain-specific, encapsulated, psychological mechanism—designed to process the relevant information, as a component of the human mind.
4. Contrast empirically the hypothesis against the effective patterns of behaviors and alternative hypotheses.

So, notice the relationship between ontogeny and phylogeny that is assumed in this methodological approach. While the starting point seems to be a functional analysis of the Pleistocene hominid selective environment, as a matter of fact, for the heuristic procedure to make any sense, we need to consider first cognitive modules, which are conceived as innate cognitive mechanisms. In so doing, the approach implies that it is only what is innate that has any phylogenetic relevance, establishing a direct parallel between a particular moment of phylogenesis and current ontogenesis, but restricted to what is modular (even if the timing of its ontogenetic expression may depend on contextual factors).

An example is the best way to illustrate how these principles work in practice. Given its obvious connection to evolution, sex and mating has been a preeminent area of research in evolutionary psychology (Buss, 1994; Symons, 1990). To begin with, it was reasoned that during the Pleistocene, women faced the burdens of internal fertilization, a 9-month gestation, and lactation, burdens that made it difficult for them to obtain the most basic resources for life—food, shelter, and protection—on their own. Therefore, there was an adaptive problem for them to solve, which led to women preferring mates more willing to provide those resources. Second, the information that might be useful in finding that sort of mate could have to do with display cues indicative of wealth, status, or a potential of provision (intelligence, hard work, ambition). Third, hypothesize that in women there exists an innate module responsible for their mate preferences, which is geared toward the marks of wealth, status, and potential of provision. On the part of males, a parallel argument attributes to us a sexual preference for the marks of youth in females (smooth skin, good muscle tone, and optimal waist-to-hip ratio), as the indicative cues of fertility to look for, which our system of preferences would be designed to detect.

To test these hypotheses, David Buss carried out an extensive series of cross-cultural studies to determine whether human mate choice shows consistent patterns the world over. He remarked that there is a broad cultural consensus about what attributes are important in a mate, and that the genders show the distinct patterns predicted. Broadly speaking, females are more concerned than males with the financial prospects of their candidate mates, and males are more concerned than females with the physical attractiveness of their partners. In his own words: "Men worldwide want physically attractive, young, and sexually loyal wives who will remain faithful to them until death" (Buss, 1994, p. 70). His conclusion is that there exists, indeed, this innate module for sexual preference. Ontogenesis, so to speak, reveals what was important in phylogenesis by making it innate.

It is not my purpose to discuss this example in more depth, although it may be worth mentioning that this conclusion relied on a statistical difference in low-rated traits (the 12th in females, the 10th in males). In other words, both sexes coincided in the four traits deemed most important in mate choice: mutual attraction, dependable character, emotional stability, and pleasing disposition. He also found that knowing where a person lives is more predictive of what he or she values in a mate, than knowing their gender. In other words, cross-cultural differences are much more important than gender differences in understanding, explaining, or predicting mating preferences.

Many arguments undermine such approach to human evolution:

a. Evolutionary psychology assumes a simplistic view of the Pleistocene human habitat. The Pleistocene ranges from 1.5 million years ago to 50,000 years ago. That is to say, it ranges over the period when our ancestors—first *Homo erectus*, then *Homo sapiens* twice colonized the world. This means a huge variety of habitats: the Pleistocene human environment includes the African Savannah, and also the caves of the Ice Age, the tropical forests of Indochina, and the fertile lands of the Middle East.

b. Evolutionary psychology requires a much better knowledge of the conditions of life of our ancestors than that which we can avail ourselves. If it is not now clear what selective pressures we are currently facing—is it fitness-enhancing to use preservatives—it seems much more difficult to speculate on the selective pressures faced by our ancestors, given our much more limited knowledge of their lifestyles (e.g., group size, patterns of affiliation, linguistic communication, daily activities).

c. Evolutionary psychology lacks a principled method for the individuation of selective problems. Is mate choice a single problem or a set of different problems? As a matter of fact, it involves many different things: choice of a first partner, extinction of a preference, maintenance of the link, when to be unfaithful, when and how to punish the partner for being unfaithful, whether to express preferences for the mates of one's close relationships (given inclusive fitness), etc. Is mate choice a single domain? I think the evolutionary correct way to pose the question is the other way around: it starts with the individuation of the structure (or device) and then asks for its function. It is when we identify a modular mechanism that we can suppose that the different things it is involved in constitute a domain, or a problem. But what we may find out may be much more complicated than evolutionary psychology envisages. For instance, we may conclude that a mechanism is modular because of a process of modularization by representational redescription in ontogenesis (Karmiloff-Smith, 1992): through practice, rather than because of an adaptive process that made this ability innate. There is still another possible notion of module, besides the nativist and the developmental ones. Think for instance of reading and writing. Current neuropsychologists and psycholinguistics consider that such abilities are served by specialized brain mechanisms, but nobody has ever proposed that they are adaptations or made possible by innate modules. It is well known that intensive practice may lead to the automatization of a process, and the acknowledgment of this fact was one of the main criticisms of Fodor's modularity thesis when it was first launched. There is still another possibility that the massive modularity approach also overlooks: that instead of serving just one evolutionary function, a mechanism may serve several. The best example here is the hand. Is its function to grasp, to gather, to pick, to catch, to seize, to snatch, to scratch, to fold, to point, to palm off, to grip, to squeeze, to handle, to handshake, to pull, to push, to fist, to grab, to tap, to knock, to strike, or to punch? And for all of these functions one hand is enough, and we have two! Beginning with a function and searching afterward for a fixed, innately specified structure, evolutionary psychology arbitrarily constrains the range of evolutionary possibilities.

d. That's why even if we were to agree on the existence of some selective pressure, it does not guarantee that the way humans adapted to it was through an innate modular system. It could also be dealt with by a multi-purpose mechanism or a general purpose ability (in the service of problem-solving). However, evolutionary psychologists unanimously reject such a possibility. According to a well-known reformulation of the usual arguments by Buss (1999), evolved psychological mechanisms are expected to be domain specific because "(1) general solutions fail to guide the organism to the correct adaptive solutions; and (2) even if they do work, general solutions lead to too many errors and thus are costly to the organism; and (3) what constitutes a 'successful solution' differs from problem to problem." (p. 52) Thus, for instance, it is possible to learn about one's enemies or about poisonous mushrooms by trial and error: a general purpose mechanism par excellence, but a highly risky process involving the exploration of a vast amount of combinatorial possibilities, and delivering nontransferable knowledge (knowing which mushrooms are poisonous does not give us a clue as to which berries are poisonous). Therefore, it is expected that we will develop special purpose mechanisms to make these discoveries.

These sort of arguments may well be useful for discrediting a view of the mind as a general purpose device only, even though up until now nobody seems to have developed a poisonous mushroom detector, in spite of its potential usefulness. However, they do not suffice to establish the massive modularity thesis, even in a weak sense. The reason is that they do not exclude the possibility of a general purpose system with a set of specialized input modules (Fodor, 1989, 2001a). The argument also faces a problem of enough time: since an innate module is a hardwired solution, it takes a long time to change in evolution, hence it is a bad strategy to follow in a changing environment. In such a habitat it is a much better "solution" to be flexible and wait for the details of the current environment before fixing the architecture, as we have argued in the first section. It seems difficult to reject the evidence that shows that the human evolutionary strategy is one of phenotypical plasticity and cultural diversity. This is the most important shortcoming of the massive modularity thesis, in our opinion: it implies a misleading view of the potentialities of development, because it restricts these very potentialities into genetically packaged modules.

This point is obviously connected with the second above: the successful colonization of multiple environments during the Pleistocene has to do with our lack of innate specialization to just one of them, the African Savannah. And it involves still another double aspect: the environmental instability caused by our own ancestor. On the one hand, the very novelties of human evolution—tools, symbols, indirect reciprocity, social norms, language, and art—dynamically transformed the adaptive landscape of our species. That's why, for instance, we are not born speaking a natural language: evolution cannot work fast enough to keep pace with the cultural changes that drive linguistic change. Besides language cannot be thought of as an environmental problem to which it would be very useful to adapt by evolving an innate module, because, *ex hypothesi*, there was no language before humans began to speak: linguistic communication was possible before some kind of innate specialization for it could evolve. So it is new human activities that shape a new and changing human social environment. It is this power for innovation, for cultural evolution, which gives the human mind its aura of evolutionary uniqueness. Other species can show greater proficiency in sensitivity to some kind of perceptual information or in carrying out some modes of behavior. It is only the human species that presents such a great range of variability, flexibility, and capacity for innovation, which gives rise to cultural knowledge and its intergenerational transmission. Such a cultural process happens faster than biological evolution. This active role of early humans in shaping their own environment has another critical consequence for evolutionary psychology: the way evolutionary psychology thinks of adaptation is as a passive organismic modification for getting attuned to the environment. But, as is also well known, human evolution involves the active transformation of the environment, not just the adaptation to its features. This is particularly true of the last 50,000 years of human prehistory, but it obviously started long before (think of tool manufacture and the use of fire, to mention but a few that date back to *Homo erectus*).

The idea, then, is to reject a universal psychological design that is somewhat inscribed in the genes and that constitutes a kind of common initial state, which development may just partially influence or modulate. This still deeply entrenched view of a universal "human nature" as innate is made possible by the ambiguous use of the term "innate." As a matter of fact, the word "innate" has at least six separate meanings, namely: present at birth, a behavioral difference caused by a genetic difference, adapted over the course of evolution, unchanging throughout development, shared by all members of a species, and not learned (Bateson, 1996, p. 2). These senses are unproblematic taken by themselves. The problems arise when these different senses are assumed to be coreferential, when they are not. Being selected over the course of evolution is perfectly compatible with changing over the course of development, as long as the environmental conditions in which the process takes place vary. Equally, it is possible that a mechanism adapted in the course of evolution presents great variability (e.g., skin color and blood factors).

As a matter of fact—for all we know—human development is intrinsically an open process, that is to say, a process in which the final stable state is not already written down in the genes or somehow already codified in the initial state. What appears to be a selected adaptation may well be the by-product of our plasticity in a stable environment. It follows that development is the key to understanding human mental configuration. And—needless to say—development makes a lot of evolutionary sense. The fact that language learning takes place during most of child development (at least, until 7 years of age), along with cognitive development, makes it possible that it plays an important configurational role as the adult human mind gets constituted.

3 The Relevance of Language for Thought: A Continuum of Possibilities

Several theoretical positions have been put forward to account for the influence of language on thought. Leaving aside purely communicative/expressive views of language, and extreme constitutivist views discussed in the previous chapter, all these positions share a cognitive view of language (Carruthers, 1996). Any such view contends that language somehow “shapes” human cognition. They disagree, though, about exactly what role language plays in, and how important it is for, cognitive architecture. A variety of intermediate positions can be found, depending on the relationship between language and thought considered and the extent of the types of thought linked to language. They range from limited influence on some kinds of concepts or processes to a more central one in making possible whole new forms of thinking. Thus, they differ in their implications for the architectonics of cognition. In general, though they avoid a simplistic mechanical model of influence, attention is paid to language components, but to loops of interaction as well.

For convenience, in this chapter we will critically present the five most relevant positions: those that have attracted the most interest and defenders, starting from a historical twentieth century perspective and continuing through to contemporary proposals. But we will do so out of a systematic, rather than scholarly, interest. We will consider the following theoretical options: relativism, cognitive restructuring, thinking for speaking, language as modular interface, and language as social scaffolding. Relativism is associated with Whorf and cognitive restructuring with Vygotsky, as the two classical twentieth-century main proposals concerning what makes verbal minds special. The other ones are contemporary views that have developed as ways to avoid exaggerations and maximalisms, as well as to provide an account compatible with the basic tenets of contemporary cognitive science—a difficult project, as evidenced in the previous chapter. They can be seen as a continuum of positions in decreasing order of linguistic influence: from those that conceive of the language-dependency of thought as constitutive to those that see language as a facilitator of some cognitive posibilities over others. Accordingly, they also differ in the role they assign language within the cognitive architecture. The following chapters will review evidence that has been amassed in recent years out of hypotheses inspired by these different theories, but we will defer the discussion of which view gets more support until the last chapter. We will also synthesize and integrate the main results and consider whether a general pattern can be consistently recognized.

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3.1 Relativism

Linguistic relativism finds its roots in Romanticism: in reaction to the supremacist attitudes of the Enlightment thinkers, who were in the business of establishing hierarchies of languages in order to find the "perfect" one (generally, the language of the author). Romantic thinkers, such as Herder, viewed peoples ("Volks") as incommensurable historical entities, whose worldviews are somehow condensed in their respective languages. In other words, language was viewed as the accumulated wisdom and repository of experience of a particular people, not better or worse than any other. All languages, as all peoples, were acknowledged to have equal rights and value, in opposition to the Enlightenment's "progressive" views. These views, which picked out the corresponding national language as the "perfect language", used it as an ideological justification for nation–state hegemonic policies and the imperialist imposition of European languages (Gomila & Comes, 2011).

This Romantic attitude found its proper place in the development of anthropology as a science in the late nineteenth century. A privileged area of research in this regard was the documentation of the Amerindian languages as their speakers were being exterminated or "reserved" (Boas, 1911; Sapir, 1924). Melded with the traditional view of the isomorphy of language and thought, this work naturally gave rise to the linguistic relativism hypothesis: what one can think is constrained or molded by the language one speaks. Whorf's originality (1956), in this regard, lies in his particular way of arguing this view and in his effort to provide evidence for this approach, instead of taking it as an obvious postulate of anthropology.

Whorf's reasoning belongs with the functionalist American tradition. Following William James' views, Whorf describes the infant development as the process of getting the "booming, buzzing" confusion of sensory experience to be organized categorically by our minds. Language provides us with a set of "ready-made" categories. By learning a language, then, we acquire a categorical system that allows us to make sense of our experience: to organize it, rather than just lexically label it. If different languages "carve nature at distinct joints," speakers of different languages will come to experience the world differently. To put the point in anti-realist terms, as sometimes Whorf did, they will come to experience different worlds. Language, from this point of view, is not just a communicative tool but also a representational one. Thus, for instance:

> *[L]anguage produces an organization of experience. We are inclined to think of language simply as a technique of expression, and not to realise that language first of all is a classification and arrangement of the stream of sensory experience which results in a certain world-order... In other words, language does in a cruder but also in a broader and more versatile way the same thing that science does. (Whorf, 1956, p. 71)*

It is true that this simplistic argument is not coherent enough: it doesn't apply to language the general point about sensory confusion. Language is thought to provide a way to structure one's experience, as if it were a salient part of one's experience in the first place. But it is legitimate to ask: How do we categorize linguistic categories in the first place? Also: Are there not categories common to all languages? Whorf said that the automatic patterns of categorization implicit in each language remain in the background, affecting our basic ways of thinking, while taking human cultural diversity (understood as different ways of thinking) for granted. In this way, Whorf could be considered a cognitive linguist "avant la lettre": language is viewed as a repository of ways of classifying and selecting aspects of experience. Whorf is interested in those aspects of our experience that are formalized in a language, by being either lexicalized or grammaticalized, like the plural or the verbal aspect. Given the background nature of these features for the monolingual speakers of each language, these patterns can only be made explicit by comparison with different languages in the context of their different cultural practices and institutions. Differences among languages are taken for granted by Whorf as something evident, along with cultural differences in thought.

It is also true that Whorf suggests in some passages that thought is carried out in the particular language one speaks: "Thought takes place in a language, be it English, Sanskrit or Chinese" (Whorf, 1956, p. 283). But this is not a core aspect of linguistic relativism. It just requires that what can be thought is configured by the categories of one's language, that one's global conceptualization of experience derives exclusively from one's linguistic experience, or the doctrine of linguistic determinism. Even more problematic are the issues of circularity that arise: how and why these different linguistic categorizations of reality appear in the first place, how languages and cultures emerge and can change, and whether the direction of causal influence on cognition is unidirectional.

The contemporary revisions of the hypothesis of linguistic relativism (*see* Gumperz & Levinson, 1996; Levinson, 1996; Lucy, 1992b) avoid the epistemological and metaphysical views of Whorf, and focus on the basic argument for linguistic relativism. In this regard, Whorf's central argument can be summarized this way:

- *Premise 1: Linguistic diversity*: languages differ in their lexical and morphosyntactic rules and categories.
- *Premise 2: Linguistic determinism*: the linguistic ways of categorizing human experience determine the cognitive ways of categorizing it.
- *Conclusion*: The categorical structure of thought varies according to the language of the thinker.

Notice that this is more a deductive schema than a well-specified hypothesis. All sentences in this reasoning admit of different degrees of modal strength, while for any of them some sort of linguistic relativism follows. The risk here is triviality, if a too weaking reading is assumed but this way of articulating the discussion helps to make the issue more clear (Acero, 2010). Thus, linguistic diversity may be underlined (Levinson, 2003) or downplayed, for instance as parametric variation of linguistic universals (Chomsky, 1988). In the same vein, the second premise affords a strong reading (all cognitive categories are linguistic), or a weak one (at least some cognitive categories depend upon the language acquired) (Kay & Kempton, 1984). Understood this way, Whorf provided a concrete program of empirical research, to find out whether, and to what extent, it is true that linguistic structure influences cognition; such a program has given rise to a lively neo-Whorfianism in contemporary cognitive science. Positive evidence for such a position has to show the role of language in differentially structuring, or formatting, our cognitive system. Empirical evidence is required to ascertain the strength of such a position: it might be the case that relativist influences do not happen across the whole cognitive system, but just in less canalized, more abstract, cognitive domains. They might show up, though, both in early learned perceptual categories, such as color or ontological kinds, and in late learned cognitive categories, such a time, which involve some kind of recoding of sensory experience. There is no need for radical constructivist assumptions ("no perception without language") to honor Whorfian effects: they may just involve overcoming initial implicit sensitivities, which are not linguistically coded, and making some perceptual aspects more salient because of the way language drives attention to them.

3.2 Language as Cognitive Restructuring

The idea here is that verbal minds involve a kind of side effect, a restructuring—or at least an amplification—of cognitive capabilities. In other words, a cognitive system, by becoming linguistic, acquires a supplementary system of cognitive representaton and processing, which transforms the basic capabilities of such a system, giving rise to new possibilities. A Whorfian effect, then, can be seen as one example of cognitive restructuring (Majid et al., 2004), but the new possibilities can be found both at the representational level and at the processual one: what can be thought and how it can be thought.

The father of this general position is Vygotsky (1934), who accounted for the flexibility and creativity of human higher cognition as made possible by language. It is not my intention here to review his work (for useful presentations of his long-standing contribution, vd. Wertsch, 1981, 1985), but just to introduce those ideas that can still be useful. Vygotsky's general project was to understand how the new generations become new members of society. From an evolutionary point of view, it is clear that our evolutionary path is one of ultrasociality, meaning that the social was the most important selective pressure our ancestors had to face (Humphrey, 1976). We currently know that infants are born with a set of predispositions for a social life (including: perceptual preferences for human stimuli, affective disposition to attachment, and mechanisms of intersubjective interaction), and that the developmental process is flexible, but structured. Vygotsky was concerned with how to account for this process that culminates with a social, mature subject. His contention was that it is the interplay of social interaction and mental activity that drives this process, and he pointed to linguistic interaction as the key mechanism in this process, for its double dimension as a mental and a social process. He formulated a "general genetic law of cultural development," according to which "Every function in the child's cultural development appears twice, or on two planes. First, it appears on the social plane, and then on the psychological plane. First it appears between people as an inter-psychological category and then within the individual child as an intra-psychological category … but it goes without saying that internalisation transforms the process itself and changes its structure and functions. (…) This is equally valid of voluntary attention, logical memory, concept formation and volition development" (Vygotsky, 1981, p. 57).

Regardless of the evolution of psychological terminology—especially, the disappearence of a "psychology of the will," replaced in contemporary discourse by talk of "executive functions"—Vygotsky's point can be rephrased in terms of a single intuition: children's abilities appear first in a social setting, to be only posteriorly mastered at the individual level. Two main concepts carry the burden of explanation of this process: interiorization and mediation (Vygotsky, 1978).

By interiorization, Vygotsky means the process of transforming open actions in a social setting (such as putting, giving, taking, and moving) into mental operations. Higher processes are thought to develop during the process of interiorization of operations carried out in the context of social interaction. Voluntary attention, logical reasoning, hypothetical concept formation, and voluntary processes, in general, become for Vygotsky individual processes made possible by the interiorization of previous social activities. Thus, the algorithmic procedure which initially guides paper and pencil substraction, for instance, provides the grounds for mental calculations after interiorization. Logical reasoning may equally be preceded by use of diagrams to carry out informational operations. Voluntary mental operations develop through such an interiorization process. To put it in more contemporary terms, offline cognitive processes can be seen as dependent on the simulation in imagination of operational schemas learned in online processing.

Mediation refers to the mechanism of this interiorization. Vygotsky was mostly interested in a particular kind of mediation: semiotic or symbolic mediation. Social activities are sometimes carried out through a symbolic medium: public language in the first place, but other symbolic media are also used, including: numbers, diagrams, the abacus, and chess figures. Of course, the infant first needs to become part of the symbolic community, to be able to publicly use those symbols. In this way, the infant can follow instructions and suggestions from others, becoming able to achieve more than he or she could do on his or her own (the notion of "zone of proximal development" refers to this socially induced potentiality). For our purposes, though, it is the process by which the ability to use the public language gives rise to the "inner speech," after a transitional phase of prívate, or self-addressed, speech, which is critical. Higher order thinking processes, accordingly, are thought to be both internal and symbolically mediated. What started as the instructions of an adult helping to solve a problem which the infant was unable to solve for herself becomes the instructions the infant addresses to herself, once she internalizes the symbolic medium which mediates the social process of problem solving. Individual problem solving reproduces what started as a social, symbolically mediated, process: it takes the form of a series of self-instructions. In a transitional stage, these self-instructions are still overt, articulated in public language even if they lack a communicative dimension. In the mature stage, articulation is supressed, and what remains is the self-conscious experience of soliloquy, of inner speech. Such an experience implies new mental contents, and also a new kind of process: open, flexible, and controlled by will.[1] Thus, Vygotsky is the first to propose a dual theory of thinking.

[1] There is something deeply misleading in the standard dichotomy between automatic and controlled processes in psychology: what could be more controlled than an automatic process? The ambiguity, in my view, stems from what's implicit in the notion of control under the "controlled" processes: control at will, but "will"—while a star of nineteenth century psychology—has all but disappeared!

The process is not restricted to language, though; mental calculations also originate in operations with numbers in a social context. It is an interesting open question whether all symbolic systems are parasitic on language (Premack, 2004), and to what extent imagination—understood as offline simulation—is the crucial capacity involved in making possible these higher order processes (Carruthers, 2011). It is worth mentioning that the argument by opponents of "images as mental representations" about the proper interpretation of rotation and scanning tasks (Fodor, 1981) was based on a Vygotskian point: they explained away the experimental findings in terms of the interiorization of familiar practices of physical manipulation of objects.

No doubt, Vygotsky was aware that all of these higher functions rely on more basic cognitive abilities. Unfortunately, his approach is not very clear in this respect. No principled account of the basic representational abilities required for becoming a symbolic agent or for the interiorization process to take place is offered by Vygotsky. In contemporary terms, he doesn't offer a complete view of our cognitive architecture, and in particular, of how natural language processing is involved in inner speech. He insists that "the interiorization transforms the very process and changes its structure and function" (Vygotsky, 1981, p. 163), but Vygotsky does not offer notions analogous to those of Piagetian accommodation and assimilation, to try to account for this process. Vygotsky's thinking has been very fruitful and stimulating, however, providing different avenues of further development in psychological research. Some of these avenues have turned into different views (such as social scaffolding), but they retain a partial Vygotskian heritage. But many views share the Vygotskian insight of higher order, flexible thinking being associated to language (Carruthers increasingly emphasizes this aspect within his "language as modular interface" view). The main difficulty, though, for a contemporary defense of the Vygotskian approach, lies in how to accommodate it within the framework of dual views of the mind (Evans & Frankish, 2008): how to conceive of inner speech, how to characterize its cognitive restructuring effects, and how to account for the involvement of the faculty of language in this new level of cognitive organization.

Nevertheless, "orthodox" followers of Vygotsky have tended to ignore these questions, and see Vygotsky as one of the fathers of cultural psychology (Werstch, 1985a; Valsiner & Rosa, 2007). They typically adopt a dialogical understanding of inner speech (Fernyhough, 1996; Frauenglass & Díaz, 1986; Ramírez, 1992; Werstch, 1985b), according to which there are two "voices" in inner speech. These inner speech voices represent differing perspectives on reality, just as the voices in external dialog represent differing perspectives on the world. In other words, it is the conversation paradigm that gets interiorized, so that the child talks to oneself as if talking to another. Or, more precisely, it is an other's voice which addresses the subject, providing instructions—the other's voice having been internalized. But as Vygotsky observed on the grounds of private speech—which he thought illustrated the features of inner speech—the latter is not like normal speech. It is not composed of full sentences, for instance; it is the result of both semantic and syntactic abbreviation, which means that inner speech bears little superficial resemblance to public language sentences (Vygotsky, 1934). It is rather a set of pointers for action, composed of predicates—which contribute to cognitive control—as a fragmentary series of verbal images. There is no room for the pragmatic dimension of figurative effects, common knowledge, contextual implicature, and conversational give and take. In inner speech—for Vygotsky—semantic reinterpretation of public language is also thought to be possible: the imposition of private meanings on public terms, the aglutination of words into new complex expressions for idiosyncratic concepts, and the infusion of the sense of public words, to load them with new associations apart from their conventional meanings. While these subjective processes of signification have fallen into disrepute in contemporary views of meaning, his approach rightly pointed out the role of enculturation in human ontogenesis (Sinha, 1996). His view saw enculturation—not as an addition to a universal human nature—but as a constitutive part of such a nature, which is correspondingly culturally diverse, and which requires a social apprenticeship (Rogoff, 1990).

A variation on Vygotskian themes—one that avoids the complexities of a dialogic understanding of inner speech, while underlining its representational and executive effects, and the importance of culture in human nature—can be found in Dennett's approach. Taking Gregory's suggestion that artifacts are means to reducing the computational charge for individuals, and are ways of broadening our behavioral repertoires (Gregory, 1981), Dennet has developed the notion of "Gregorian systems" (Dennett, 1996, 1997) to mean evolutionary beings whose adaptive strategy lies in accumulating and transmitting knowledge and artifacts. Hominid evolution epitomizes this strategy, which can be summed up with the slogan: "Culture is our biological strategy." This notion is heavily connected to the "social scaffolding" approach, as it also starts from an analogy to Dawkins' notion of "extended phenotype": just as a bird's way of life cannot be severed from its nest, a human way of life is intrinsically cultural. Culture is not something we have to take out to get to the "real human mind." Without it, there is no human mind at all (for similar views, *see* Bruner, 1990; Donald, 1991; Nelson, 1996, 2005).

However, Dennett parts company with "extended mind" views, which emphasize the "social scaffolding" of a public symbol system (Clark, 1997, 1998, 2008): he is not so much interested in the common heritage that amplifies each mind's cognitive power, but rather on the impact that symbolic systems—particularly language—have on human minds. Thus, language it is not only a tool that facilitates the transmission of knowledge in an economic way, but also generates a reorganization of basic cognitive processes. Dennett does not use the term "interiorization," he focuses, rather, on the new cognitive properties that come about through the acquisition of the grammatical structure of language. These new properties concern both a new kind of "language-like" representation and the kind of inferential relations that this new format makes possible. In his terms, language creates a new, propositional "virtual machine," over the basic cognitive architecture, which he sees in connectionist terms (Dennett, 1993, 1997).

The main effects of such a new level of representational powers are: active processing (he avoids the term "private speech"), recoding in a symbolic format (a format that facilitates public sharing), and conscious access. The cognitive effects of language, then, come from the new representational level which it generates, with its corresponding propositional representations and inferential processes, plus the self-report and self-instruction that goes with it as the "language of conscious thought"

(Gomila, 2000). In other words, Dennett restricts the LOT to a higher order, serial level of organization, compiled over the sort of parallel machine that our brain is. Explicit rule-following, then, is only possible for verbal minds, which recode and rewire the contents and processes of implicit minds. In his account, though, consciousness is the Achilles' heel, given Dennett's goal to explain away sensory consciousness. It is not clear how the propositional representations posed can become conscious—as required by the new computational level of organization postulated—in order to carry out the conscious cognitive control role it is assigned. Nevertheless, when such "scruples of consciousness" are overcome, this cognitive role for language in turning implicit into explicit cognition and making it systematic and controlled makes a lot of sense.

A parallel strand views language as the key to metarepresentation (Bermúdez, 2003). Verbal minds—according to such a view—differ from nonverbal ones in being able of "intentional ascent" of representing their own representations. This is made possible by natural language, which provides the right vehicle for reflexive conciousness. However Bermúdez's proposal is guided by the problematic assumption that linguistic cognition is conceptual and nonlinguistic cognition is nonconceptual—a notion of his own definition, whose justification is epistemological. The notion that language provides the grounds for metarepresentational thinking, though, is a powerful idea, for which we will find some empirical support.

3.3 Thinking for Speaking

The concept of "thinking for speaking" is a fallback position from full-blown relativism. Instead of claiming that all of our concepts are acquired through language, it is claimed that while concepts are language-independent, language does prime us for some of them over others. It is clear that languages code certain aspects of human experience in a formal way—through lexicalization or through grammaticalization—as per Whorf; languages also differ in the categories for which they code. Thus, for instance, many languages mark number or person, aspect or time, in a normative way, as part of the system that each language constitutes. A speaker of a language—by learning it—is driven to pay attention to those aspects of human experience in particular, in order to become a competent speaker. Given that languages may differ in the number of aspects and which ones they mark, differences between speakers of different languages that mark these aspects differently are to be expected. In this theory, language does not have a structuring effect on our conceptual resources, but each language biases some concepts over others, given their selection of categories and aspects they require to specify in speaking.

This view was proposed by Slobin: "[T]he expression of experience in linguistic terms constitutes thinking for speaking – a special form of thought that is mobilized for communication. ... In the evanescent time frame of constructing utterances in discourse one fits one's thoughts into available linguistic frames. 'Thinking for speaking' involves picking those characteristics of objects and events that (a) fit some conceptualization of the event and (b) are readily encodable in the language. I propose that, in acquiring a native language, the child learns particular ways of thinking for speaking" (Slobin, 1987, 1996, p. 76). The typical evidence this proposal looks for as support consists in differences in attention paid to the elements of a situation, as a result of the different ways in which their respective languages code for those elements. Thus, if verbs in one language are marked for aspect and verbs in another language are not so marked, it is expected that speakers of the first language will have to pay attention to whether processes are completed when they want to speak about such processes, in a way that speakers of the second language will not need to do.

Notice the double timescale of linguistic influence on cognitive processing that Slobin distinguishes. On the one hand, there is the fast timing of language production, which is the one he underlines. On the other hand, there are robust, systematic ways of conceptualizing events and situations. Surprisingly, Slobin fails to establish a closer link between the two. Such a link could be expressed in a slightly modified slogan: instead of "Thinking for speaking," "Thinking for posterior speaking": thinking processes should already be coded in linguistically compatible terms, to be easily accessible. In other words, given the central role and strategic advantage of verbal thinking, a permanent effect on other forms of thinking is expectable. This long-term, structural effect would begin during the process of language acquisition and would exert its influence along ontogenetic development. In learning a language, according to this modified position, one learns a way to encode experience in a shared symbolic system. In speech, this network of grammatical specifications drives the speaker's attention to the required aspects of experience. While Slobin emphasizes production, our modification also makes it relevant to understanding: in order to understand another's speech, one has to process those concepts that language encodes, thus giving them still more weight in conceptualization ("thinking for understanding another's speech"). As we'll see below, this version of "thinking for speaking" is closely related to the "social scaffolding" position, in that both views underline complementary dimensions of language: representational and communicative, which determine each other, but avoid the metaphysics and epistemology of Whorf. Slobin is careful, anyway, to avoid commitment to anything stronger than a ocasional linguistic bias on the contents of thinking in general: it is for the purpose of communication that thinking contents have to be "streamlined" (my metaphor) to match the conceptual (grammatical, lexical) preferences imposed by language. And he skips the question of how to conceive of this "individualistic" thinking in itself, though he implicitly rejects inner speech as the vehicle of this individual cognitive processing.

An important consequence of this approach is that a lexicalized content is not processually equivalent to a content that requires a paraphrase to be expressed. The issue is not one of intertranslatability anymore, but one of expressive economy. This consequence found convergent support in Hunt & Agnoli's (1991) modest strategy to vindicate cognitive differences related to linguistic ones. Their contention is that language influences thought by generating cognitive habits: languages differ as to which linguistic habits they foster. Extra attention given to a concept thus becomes a habit, which can give rise to significant differences in reaction time, for instance, which are thought to indirectly indicate differences in computational complexity. The linguistic salience of a concept may also show up in the higher reliability of its memory. Given that standard psycholinguistic effects may be on the order of 20 ms, finding such processing effects due to linguistic differences may not be easily disregarded.

Therefore, the central idea of this proposal is that each language makes some concepts, those the language requires marking, more psychologically prominent and accessible. Speakers of other languages, with different formal requirements, are not blind to those concepts, even if they may have a harder time grasping them. Conversely, this position also suggests the possibility of a differential susceptibility to linguistic influence: some cognitive domains might be more easily variable and diverse, and hence linguistic diversity could have a greater impact in prompting cognitive diversity. Abstract concepts, such as mathematical and temporal ones, have been proposed as prime examples of this (Boroditsky, 2001), given that we do not base them on specific direct sensory motor experience, but rather on spatial metaphorical schemas. Temporal concepts are not so constrained by physical experience, thus they can be more variable across languages and cultures.

3.4 Language as Interface Between the Modules

The theory of language as interface between the modules is an attempt to concede to language some cognitive impact, without challenging the general cognitivist architecture of modules and the language of thought as representational vehicle. Its proponents' are close to the evolutionary psychology's massive modularity thesis (Barkow, Cosmides & Tooby, 1992; Carruthers, 2006; Pinker, 1997). As discussed in the previous chapter the thesis requires a weakening of the notion of a module, until it barely resembles the Fodorian notion (Fodor, 1983). The cognitive architecture of the mind is conceived as a set of specialized, domain-specific, modules, which do not only provide specialized input to the system, but also are responsible for conceptual inferences. These different modular conceptual processes are thought to take place in a variety of already propositional, language-of-thought-like representations, but in a disconnected way. Language, which is thought also to consist of a set of such modules (Carruthers, 1998a, 2006), would be different from these other conceptual modules in this respect: it would be capable of receiving, conjoining, and reporting information derived from any other conceptual module. In this way, it would become the informational interface among the modules, making possible the integration of their respective outputs, giving rise to a higher level of cognitive processing (Carruthers, 1996, 2002, 2008; Spelke, 2003). Language is said to underpin the flexibility and integrability of content that characterizes human cognition.

However, it is not immediately obvious how language can play this role. In Spelke's version, the interface is made possible because different sources of information can be combined into the semantic structure of sentences. In Carruthers' version (Carruthers, 1996, 1998b, 2011), what makes language cognitively relevant is that such semantic structures take a control role in cognitive processing explicit verbal thinking is thought to play this cognitive control role by being "globally broadcasted" (Baars, 2002) to the whole system: in this way it can affect all the other modules' activities. However, it is not completely clear how such "global broadcasting" can take place in a modular architecture or whether or not language has effectively produced a qualitatively distinct kind of conceptual information along the process. By definition, no module is supposed to be capable to "parse" such verbal content packages (Vicente & Martínez-Manrique, 2008).

The basic idea, though, is of Vygotskian inspiration, especially in the last versions of Carruther's view (such as Carruthers, 2011). The notion of "inner speech" is revised within the framework of the working memory construct (Baddeley, 1996) as part of the phonological-articulatory loop. Just like in Vygotsky's theory, inner speech is viewed as a means for cognitive control. Carruthers suggests that it is as a conscious auditory image that linguistic representations intervene in thinking processes of a special kind: conscious propositional thinking, such as believing, desiring, and reasoning. Such processes are assumed to involve imagined linguistic sentences: either heard or produced and using either auditory or motor images. Hence, it is language, itself, that is considered the vehicle of those thought processes—a position different from the Dennettian reviewed above—language acquisition triggers a new kind of mental representation.

Carruthers thus views this role for language as part of his defense of a dual theory of thinking (Carruthers, 2006, 2008), in which this higher level of cognition fuses both propositional content and conscious processing through the intervention of linguistic, auditory-motor images. Paradoxically, he assumes that the basic level of cognition also depends on a variety of languages of thought and inferential computational processes, which can only be interfaced through this new, linguistic means. So, the difference between both kinds of processes is not defined in terms of content or representational format, but accessibility and offline processing ("mental rehearsal"). Again, this is problematic: it is difficult to square the idea with a massively modular cognitive architecture, full of specialized systems.

Carruthers offers several arguments in support of such a view. On the one hand, he points out that we have immediate, direct access to the contents of our conscious thinking, rather than inferential or interpretative access, as is the case with nonconscious thinking in which confabulation is frequent. This difference can be explained if conscious thought occurs in an intrinsically conscious vehicle, such as verbal images. Second, these conscious thoughts correspond to a personal level of organization, rather than a subpersonal one: it is the level of the unity of consciousness, of deliberation, of weighing alternatives, and of making a decision. In other words, because the functional properties of this higher level are different, the representational medium has to be different. Finally, the seriality of such higher level thinking can be accounted for as derived from the seriality of consciousness. For Carruthers, the linguistic symbol is the one that makes its content immediately accessible, as private speech does and as images do in general.

However, such arguments fail: the phonological-articulatory loop of working memory is standardly defined as a short-term memory store where auditory-motor images can be rehearsed; however, it just contains auditory-motor information, and not its meaning. Carruthers' theory, on the contrary, requires for his "verbal images" not only to be purely auditory-motor (as "significants"), but also to activate their corresponding meanings (as interpreted images) to be able to play the functional role attributed. But such meanings go beyond auditory-motor images *per se* (as we can rehearse a verbal image we don't understand). As a way out, Carruthers suggests an analogy with visual images: we are immediately aware of what we visually imagine (Kosslyn, 1994) through a self-generated process that involves the visual processing of such experiences. Similarly, we are also aware of what we verbally imagine, but this involves the corresponding syntactic and lexico-semantic processing required for understanding this type of self-induced experiences. This further lexico-semantic and syntactic processing (which is supposed to involve subpersonal, modular processes) is needed to access the content of verbal images. Given their modularity, however, it is not clear how the outcome of those modular processes can have the executive role it is ascribed.

Thus, Carruthers' "inner speech" is something different from Vygotsky's, which is conceived as an internalization and simplification of private speech. To come back to some of the threads discussed in the previous chapter, the temptation to think of the content in logicist terms, as a representation which can be precise and determined, drives Carruthers' search for a suitable vehicle to carry out such a role. In so doing, though, he also falls prey to the problem of the semantic underdetermination and context-dependence of linguistic sentences (Vicente & Martínez-Manrique, 2005). As we have seen, cognitivism cannot avoid the well-known challenges of psychopragmatics: among them the context-dependency of thinking that takes place in natural language. Another possibility, more congenial to Vygotsky's theory, is to reject that natural language sentences are the representational vehicles for higher level thinking, and to view internalized language—or inner speech—as a driving force in thinking ("language for thought," Frawley, 1997; *see* next section). Even if derived from natural language, inner speech might be better conceived—not as an internal representational code—but rather as a specialized subsystem for cognitive control: a mechanism of reflexive consciousness.

Carruthers' proposal, in addition, has a paradoxical flavor: it tries to rejoin what has been traditionally separated: thinking and images. His notion of verbal images is reminiscent of that of William James (1890). As Fodor nicely sums up (Fodor, 1975), images are not the right vehicles for propositional contents (Fodor has finally accepted that there may be other kinds of contents—nonconceptual contents—in his 2008 book, but the general points about their content stands; Gomila, 2010). However, Carruthers claims that a special kind of image—verbal images—is thus appropiate. As such, though, these images are just "forms" or "signifiers"; their content depends on something else. Interpreted images are a different kind of entity, which are not equally immediate and direct.

There is another reason for concern, at a theoretical level, with Carruthers' proposal: its commitment to cognitivism as the explanatory framework for all cognitive processes. Dual theories of cognitive processes need not, and generally do not, adhere to such an assumption, which constitutes a roadblock for a role of language in cognition. The basic cognitive level of fast, automatic, unconscious processes cannot easily be viewed as inferential, rule-based, and symbolic (even if the rules are heuristic rather than algorithmic), given the important role of sensorimotor grounding and coordination involved at this level, and the deep theoretical problems such cognitivist approach faces (Gomila & Calvo, 2008).

3.5 Language as Social Scaffolding

This final position restricts Vygotsky's theory to the idea of social interaction—and particularly symbolically mediated interaction—as the scaffolding of human development. Language is conceived of as an external symbolic system that drives and facilitates individual cognition, but the proponents of this theory part company with Vygotsky and do not think that it also changes human thought. Human minds are social, culturally constituted minds. Linguistic symbols, just like other kinds of symbols and other social tools in general, allow the individual to externally discharge cognitive processes. Like adding with the help of an abacus or with paper and pencil, cognitive tools amplify human cognitive powers—without changing their original powers.

Frawley's (1997) contribution can be seen from this standpoint. It was a pioneering effort to reopen the case for a cognitive view of language, when it still was taboo. Naturally enough, his main idea conformed to mainstream Fodorian psycholinguistics: language, given its social and cultural use, constrains the set of possible computational possibilities. This provides a heuristic way to overcome the frame problem: the problem of an exponential explosion of possibilities to consider from an algorithmic point of view. It is an original version of the idea of language as social scaffolding (Bruner, 1990) for mental development. According to this view, language does not affect cognitive architecture, but facilitates processing by making some options—some alternatives—more salient or prominent, and by offering an external means of representation and "calculation," which can be used once mastered (*see also* Jackendoff, 1996, for a similar view). Natural language plays the role of a facilitating mediator between the internal processing and the external environment. Tomasello (1998) can also be partially viewed as an exponent of this approach: he places the key evolutionary change in hominid evolution in a special form of social learning; symbols and language just constitute part of the cultural heritage each generation transmits to the next, in what he call a "ratchet effect." The human mind is prepared to learn what is in its social environment, which becomes richer and richer with each new generation.

However, it is Clark (1997, 1998, 2008) who has been the most sustained proponent of this "social scaffolding" approach. His is clearly a "tool" conception of language as an "organon"—an instrument—for cognitive tasks, even if Clark does not pay enough attention to an "internal" view of language, to what kind of competence such mastery of language requires. His examples, though, tend to be of written language as a way to reduce the charge of memory—from books to shopping lists to Post-it® notes—rather than of language *per se*. His emphasis on language instrumentality goes hand in hand with the notion of plurifunctionality. In contrast to simple tools, language is plurifunctional. Just as the human hand is required for many different tasks—not a single one—language has multiple and varied functions. Clark mentions, in addition to the transmission of propositional information, other functions that language plays, like being the external support for individual cognitive tasks (just as in Venn diagrams), and the representational reformatting—or recoding—of sensorimotor schemas into a more abstract format (following Karmilloff-Smith's notion of "representational redescription," Karmiloff-Smith, 1986, 1992). His theory posits that language accomplishes these functions, but does so without changing the basic parallel and associative structure of our pattern-recognition general workings. Language also plays a role in the "second-order cognitive dynamics"—another term for metacognition or thinking about thinking—as in self-criticism, self-monitoring, and self-assessment; this is so because thoughts expressed in words become objects for further cognitive processing. Linguistic "objects" are supposed to be context-independent, modality-neutral, and representationally economical: properties that make them stable and abstract enough to apply to them the second-order processes of quality control. Clark also mentions Vygotsky's "area of proximal development" as an example of the instrumentality of language, which makes it possible with social help to carry out a task one could not do alone. Clark borrows Bruner's notion of "scaffolding" to refer to those cases where the cognitive cooperation of others (in interaction or through the repository of knowledge stored in public artifacts) furthers what one can do by himself or herself.

This theory is problematic, in that it is not clear how such public recoding can have a cognitive impact without a corresponding representational effect. To resort to a different symbolic system, arithmetic functions may need the help of public symbols to make the numbers and operations concrete, but to operate with them we first need to master them: to learn to count and add, for example. We may use finger counting in the beginning, but at some point we are able to "internalize" the public operations: to do them without anything external. While Clark appeals to Vygotskian notions of "internalization" and "private speech" as self-directed instructions, he does not see these processes as a sort of cognitive restructuring, but just as a kind of "control loop" that doesn't change the workings of the mind. Hence, Clark is not aware of the difficulties this creates for his position (and for the "extended mind" view in general). The difficulties include: how a parallel and associative architecture is able to deal with the rules of language, how such rule-like properties may appear in the first place, and why it is that such "associative engines" get improved by using external symbols and propositional, serial representations. More poignantly, there is the problem of how his notion of "interiorization" can make sense, given the lack of open behavior. Reducing it to the reenactment in imagination (some sort of simulation or emulation) of the sensorimotor patterns involved in the manipulations of such instruments comes short of explaining their symbolic, semantic nature. On the other hand, in equating language to any other symbolic instrument, it is deprived from having a special role in cognitive architecture (as a special kind of symbolic means, due to its special semantic properties). In other words, Clark's argument more naturally supports a conclusion of representational enrichment for verbal minds. Maybe he is wary of hybrid architectures, so he emphasizes the "extended mind" perspective.

Presented this way, these different approaches appear to be systematic rivals; in practice, though, these distinct theoretical ways of conceiving of the relationships between language and thought are the result of a historical process of reflection, driven by even more general views of the human mind and cognitive architecture, and by new evidence. In addition, the earlier theories are more ambitious than the later theories, given that they differ in the importance they attribute to the role of language in the shaping of thought. Some of the approaches single out the same effects of language, for example: labeling, categorical effects, metarepresentation, salience-based selective attention, and executive effects. On the other hand, they can also conflict: linguistic determinism clashes with the emphasis on cognitive flexibility.

Therefore, it is instructive to appreciate the continuum of theoretical possibilities, as well as the critical points that push one particular proposal more toward a cognitive rather than a communicative view. Despite the fact that some theoretical positions have been "despised" at some moment as "crazy" or "ridiculous"—and keeping in mind that not all of them can be true at the same time—it is instructive to be able to detach oneself from one's favorite position to consider alternatives and the axes of disagreement. False theories can be useful for scientific progress. Moreover, different theories emphasize different phenomena or dimensions of the interplay of language and thinking. A satisfactory theory, however, has to aim to account for all. In practical terms, this point amounts to the requirement that cognitive theories cannot ignore the communicative function of language, just as communicative views of language cannot afford to ignore the cognitive implications of language.

These different theoretical approaches should make empirical predictions, but it is not always easy to differentiate between them. Empirical evidence that favors a cognitive view of language might not equally provide support for one view over another. Conversely, evidence obtained from a particular theoretical standpoint might be better explained from another standpoint; or it can make better sense when conjoined with some other result. For these reasons, it may be more convenient to start with the facts—the evidence—in order to discuss in Chapter 8 which theoretical approach gets more support from the facts and can better explain them. In the following chapters, then, we will review in historical perspective the important wealth of research carried out in recent years, which unquestionably gives new hope to the theory of a role of language in cognition. We will use two main metaphors to structure our discussion: language as lens and language as tool kit (Gentner & Goldin-Meadow, 2003). Language as lens refers to the influence of language on how we conceptualize our experience: from the categorical effects of language on cognition to attentional and similarity effects. The methodological approach involved here is cross-linguistic: once a linguistic difference is spotted, research considers whether it is followed by a cognitive difference. The next two chapters will review this kind of research: chapter four will focus on lexical differences; chapter five will focus on morphosyntactic differences. The difference is not clear-cut for some dimensions—like time—which may span both lexical and morphosyntactic aspects; in these cases, we have opted for some other form of coherence. The second metaphor, language as tool kit, underlines the amplifying role of language on cognition. It is more properly centered on the difference between nonverbal versus verbal minds, which complements and reinforces the cross-linguistic comparison. The material is also organized into two chapters: chapter six is on representational effects; chapter seven is on processual, or executive, effects. Again, there will be some interdependency of both dimensions, but separating them makes for a clearer presentation.

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4 Language as Lens: Lexical Differences

As we have already mentioned (in Chapter 1), there is plenty of evidence of linguistic influence on verbal tasks. However, the claim that language shapes our thinking involves the further issue that even in nonverbal tasks or processes, such as perception, navigation, or memory, language still has a constitutive influence. To determine how deep this influence goes, and hence which theoretical position is most empirically supported at this point, is our goal. However, attempts to test the Sapir-Whorf hypothesis are our natural starting point. The initial challenge, from this point of view, is to prove the influence of language on nonverbal cognition. There already exists a long tradition of studies that followed Whorf's approach to the relationship between language and thinking, with inconclusive evidence (Brown, 1976, 1986, for reviews of the first decades of research). There have also been criticisms of Whorf's account of the Hopi evidence he used as grounds for his view (Malotki, 1983; Martin, 1986), and even of the repeated commonplaces associated with his name, such as the innuit's variety of terms that refer to snow, but unrelated to his proposal (Pullum, 1991). During the eighties and nineties, he became a target of mock and ridicule: even his anthropological qualifications were challenged. However, his hypothesis keeps capturing scientific imagination and has found new empirical evidence.

This tradition is mostly concerned with two levels of language: the lexical and the morphological. The basic methodology, inspired by Whorf himself, consists in finding some sort of structural difference between two languages—at the lexical or morphological level—to investigate whether speakers of both languages also show differences at the cognitive level related to that linguistic feature. The difficulty lies in finding an appropriate task to measure such differences—one that is not verbal—because with a verbal task, the differences in performance could be due to the linguistic differences, themselves. Hence, methodological discussion will be an important dimension of this review. To begin with, though, it might be useful to be aware of some of the methodological options to be avoided: to restrict the study to just one language; to privilege one's categories in comparative studies; to focus on a marginal feature of a language; or to rely on a verbal task. It is also useful to remember that the standards in this area cannot be made artificially more stringent: if mainstream experimental research honors effects of 50 ms or less—or effects that account for less than 10% of the variance—it would be unfair to change the rules when it comes to measuring the influence of language on cognition.

In this chapter, we focus first on lexical effects, starting with the most studied aspect: color vocabulary. We will also review studies focusing on the lexical differences among languages of space and number. In the next chapter, we will focus on

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studies that chose morphosyntactic differences. While these studies have been mostly comparative, some other methods of collecting evidence will be considered, when appropriate, to discuss whether or not language's role is that of a lens that filters how we see the world—and whether it is a lens that allows for no choice of alternatives.

4.1 The Color Terms Saga

Languages clearly differ in their color vocabularies (D'Andrade, 1989). Color is an outstanding perceptive dimension with a neurophysiological-dedicated system to make it possible. In addition, color can be described in physical terms. These three properties make it a perfect variable for testing whether one's language influences how one perceives the world in a noncircular way, given the availability of the language-independent, physical characterization of the color stimuli.

Four phases can be distinguished in the history scientific research carried out on the nonverbal cognitive effects of color terms, in the effort to test the linguistic relativism hypothesis. After an initial period of positive evidence, a second phase started with the influential work of Berlin and Kay (1969), which challenged the hypothesis; a third phase involved a debate of fundamentals in an effort to clarify the issue and establish requirements on evidence; finally, the fourth is a return to the initial approach, but with new experimental paradigms and new linguistic examples to consider. Given the methodological continuity and the general influence of this debate, we will pay special attention to its development because of its leading role in the development of research on the cognitive effects of language in general.

4.1.1 Initial Phase

During the initial phase, the goal of the research was to try to correlate a linguistic variable with a cognitive one within a linguistic community. In this regard, Brown and Lenneberg (1954) showed that a stimulus can be better memorized (recognized), more easily coded, and more precisely communicated by the linguistic community, when it is lexically labeled by the speakers. In other words, the more intersubjective agreement in the lexical denotation of a stimulus, the better it will be remembered in a recognition trial. This result suggested that lexicalization is an indicator of collective cognitive salience for communicative purposes (Lantz & Stefflire, 1964). Conjoined with the diversity of color terms in different languages, it invited the further inference that by learning the language, one learns the perceptual saliences that allow for successful communication and precise identification. Evidence for this claim was founded in the comparison of Mayan and Spanish speakers: when shown the same chips, Mayan and Spanish speakers differed in their memories, a difference interpreted as due to differential codability in the speakers' languages (Stefflre, Castillo Vales & Morley, 1966).

In parallel, linguistic anthropologists worked on a project to study in detail the color vocabularies of as many languages as possible. At first sight, it appeared that languages can vary without any restriction on their numbers of color terms or on their respective spectral extensions (Conklin, 1955). This evidence is compatible with the Whorfian idea that languages play a central role in the construction of reality—in an arbitrary and conventional way—and that speakers see the world through those linguistic categories they acquire in learning their languages.

4.1.2 Second Phase

A clear transition to a different mainstream conception was triggered by the classic work "Basic Color Categories" (Berlin & Kay, 1969). In this work, 20 languages were selected out of a repertoire of 98 languages. Their color vocabularies were selected, and their perceptual extensions were studied. The critical stage in the study consisted in the definition and selection of a language's "basic" color terms. The method consisted in first asking an informant (a bilingual resident of the San Francisco bay area) for the color terms of their native language. From them, the "basic" ones were selected applying criteria of lexicalization, nonsubordination to another term, frequency of use, and specificity (only with respect to meaning). In the third part, informants were shown chips of color and asked to choose the one that best exemplified each basic color term; they were then asked to select those chips to which it could be reasonably applied.

On the basis of their study with the 20 languages, Berlin and Kay concluded—against the established view of the time—that color vocabularies are not conventional or arbitrary, but follow some general principles. On the one hand, "basic" color terms are limited to 11. More important, while languages may differ in how many of these basic color terms they include, their differences follow a pattern: an order of preference of inclusion. If a language just has two basic color terms—as the Dani of New Guinea—these terms correspond to "black" (black, dark) and "white" (light, warm). If there are three, then they will correspond to black, white, and red. In the next stage, green or yellow follows; then followed by the other. Blue follows in stage 5, and brown follows in stage 6. The other basic colors are: pink, orange, purple, and gray, and more diversity is possible with their inclusion.

Second, Berlin and Kay argued that color vocabularies are organized around focal colors: those colors that are universally perceived and experienced. In fact, the first six color terms correspond to the six Hering opponent primary colors. They found considerable intercultural agreement in the best examples of their corresponding color terms. Differences notwithstanding, they conclude that all humans see the same "focal" colors, even if they do not have a term to denote them as such.

This new approach was further developed by Eleonor Heider (later Rosch), through a new theory of concepts and categorization (Heider, 1972a; Rosch, 1975; Rosch et al., 1976). According to this theory, psychological concepts are not definitions or intensions, but more or less a set of features that determine a prototypical structure, with some examples as best representatives of the concept, while others share with them just a loose "family resemblance." Basic concepts—in their turn—are supposed to be those that are learned first: those that are lexicalized and easily imaginable. In this way, she also offered a reinterpretation of the results of the first phase: it is because some colors are focal that they are lexicalized and intersubjectively agreed upon (Heider & Olivier, 1972). In the same vein, her work with the Dani (Heider, 1972b) offered evidence that people with just a couple of color terms in their language found it easier to learn and remember terms for the prototypical representatives of a focal color extension than for the nonrepresentatives, even if they lacked a term for those colors (Olivier & Heider, 1972).

The clearly anti-relativist results gave rise to a lively program of transcultural research to further Berlin & Kay results (Berlin & Berlin, 1975; Berlin & Kay, 1991; Kuschel & Monberg, 1974). Thus, for instance, while in Quechua there is just one term for blue and green, it was found that speakers of Quechua may classify the exemplars of their single term separately (Davidoff, 1991). On the other hand, further support was thought to come from advances in the physiology of color that were interpreted as providing evidence for a biological basis for focal color perception (Bornstein, 1973, 1975; Kay & MacDaniel, 1978). Categorical perception of color was also found in prelinguistic children (Bornstein et al., 1976). In conclusion, this phase of research turned the relationship between language and cognition upside down: instead of showing the influence of language on thought, it tried to demonstrate the influence of underlying perceptual-cognitive factors on the formation and reference of linguistic categories.

4.1.3 Third Phase

While this contribution became part of mainstream cognitive science—providing support for a decoupled, peripheral view of language with an emphasis on the common, universal, perceptual, and cognitive categories of the human mind—it did not go unchallenged. The reaction against this universalistic stance started with methodological criticism and the clarification of the sort of evidence required to support general, theoretical views of the relationship between language and thinking. As a result, in the fourth phase, we have witnessed a growing sophistication in research paradigms, a broadening of languages considered, and a renewed collection of evidence confirming the influence of spoken language in perceptual categorization. The reedition in 1991 of Berlin & Kay (1968) book bears witness to the interest of the debate.

Let's consider the methodological debate first. As already mentioned, Berlin & Kay's original survey was based on one bilingual informant, resident in the San Francisco bay area, for each of 19 out of the 20 languages considered. As long as they were all English speakers, in addition to speakers of the language they informed about, perceptual commonalities could be due to the shared knowledge of the English language. In addition, most languages considered were written languages of industrialized societies—17 out of the 20—calling into question an unbounded generalization of the results of the study to all languages. Third, the artificiality of the stimuli used—chips of color, taken from a Munsell color space—implies a rather abstract conception of color as a property of light—specifiable by wavelength, saturation, and hue. The more common understanding of color as a property of objects is one in which the texture or the gloss of their surface can also play a role (Simpson, 1991). This "abstraction" of the referent coheres as well with the "abstraction" involved in the definition of "basic" color terms: only those terms that denote colors in the abstract are selected. Thus, for instance, we may have color terms that are specific to some kind of substance. In English, for instance, "blonde" is a color of hair (and people with that color of hair); in Spanish, its corresponding term, "rubio" applies not just to hair but also to tobacco. In addition, color terms may originate in objects that happen to be prototypical of such a color ("emerald" or "indigo"). In their selection of basic color terms, Berlin and Kay included terms like "orange" and "pink" as basic, which in English may have already overcome their original objectuality, while still retaining it in other languages—like in Spanish, in which the fruit and flower meanings are still prevalent, which would make them nonbasic. But it could also be the other way around: Italian has four "abstract" terms for blue (blu, celeste, azzurro, and turchino). Some of them originated in one of those particular ways—as an object color or as applied to just some objects—but just blu was considered basic. This may be counted as a bias in favor of the English vocabulary in deciding which colors count as basic. In a similar vein, Lucy (1996) reports that in Zuni, a language from the North American Southwest, two terms correspond to the English "yellow": one term is a verb and applies to things that become yellow on ripening, while the other is an adjective like ours (either in English or in Spanish). Languages may also include extrachromatic color terms, such as dryness or freshness (Lucy, 1997) and terms referring to multisensory experiences of color and taste, such as in Tzeltal (Brown, 2011). All of these examples do not count as basic, in the Berlin and Kay procedure. Basic color terms, then, are just a small subset of our color vocabularies, thus maximizing the possibility of perceptual common ground among speakers of different languages by restricting the number of terms considered.

As a matter of fact, Berlin and Kay were aware of the seeming correlation between the size of the color vocabulary and the cultural complexity and technological development of the linguistic community. This general tendency toward diversification and precisification in developed societies can be understood as an instance of a general pattern: color terms, as any other lexical items, are not in the language out of an interest in systematic taxonomy of reality, but as the repository of culturally noticeable features and diferences. Individuals, through socialization, become competent at recognizing and communicating them, even if they may be able finer grained discrimination (Sahlins, 1976).

Another cause for concern was the assumption that color focality could derive from visual neurophysiology, even for primary colors. It was discovered that retinal photoreceptors, while traditionally associated with blue, green, and red, in fact are not so aligned to their respective wavelengths (Conway, 2009, for a recent summary). Van Brakel rejected the idea that neurophysiological constraints can account for color categorization (Van Brakel, 1993; Saunders & Van Braekel, 1988).

It was also claimed that Berlin and Kay's main result—that there is a universal pattern of increasing complexity in color vocabularies—does not hold. Many counterexamples, coming from unwritten languages of nonindustrial societies, were put forward. Thus, a language may have a unique term to refer to blue, yellow, and green (MacLaury, 1992) or to blue and green (Kay & Maffi, 1999), thus contradicting the conclusions drawn by Berlin & Kay. Rosch's interpretation of the Dani evidence was also challenged (Davidoff et al., 1999; Robertson et al., 2000), revealing an influence of language on the color memory task of Heider and Olivier (1972), even if just through the speech rehearsal of the color names. The fact that nonlinguistic tasks can be transformed into linguistic ones as a way to improve cognitive performance became a relevant issue to consider and control for.

4.1.4 Fourth Phase

The outcome of this debate was not a rejection of the notion of basic color terms, but rather a heightened awareness of the need to be more careful in experimental research in two directions: in greater experimental control in looking for cognitive effects of such different vocabularies; and in an ambitious world survey of color vocabularies, in order to assess the claim of a universal pattern of increasing differentiation of colors.

To begin with the first count, some works focused on color discrimination tasks to renew the classical work on color codability and to assess whether the categorical effect—the fact that discrimination is easier between category than within category—in color perception is sensitive to linguistic differences in establishing categorical borders. The categorical effect was studied as a way to show that categorical perception is sensitive to language learning, an obvious fact when phonemic categories are considered. Lucy and Shweder (1979) showed their participants three color chips: two of the same color and one slightly different from the other two. They were asked to select the two same-colored ones. English speakers' performance was better for focal colors, which is coherent with the idea of focal colors as more distinctive perceptual events. But they were also required to communicate to a partner which chip they had seen, from chips of similar discriminability. The partner had to identify the chip being described: a study of codability. Linguistic codability was shown to be related to the ability to recognize chips in a memory experiment: the longer the retention period, the better the linguistic effect. Lucy and Shweder (1979) interpreted their results as consistent with Stefflre's studies, in showing that even if language does not influence perception, it influences memory: in particular, noniconic, longer term memory. The basic mechanism is assumed to be labeling, as a form of information recoding for memory.

However, the work by Kay and Kempton (1984) also supported the role of linguistic categorization in perception through different categorical perception effects across languages. It was a kind of turning point because the researchers were especially careful to satisfy the highest methodological requirements in a way that has been very influential. In Tarahumara, a Mexican indigenous language, there is just one term for the part of the spectrum that we divide between blue and green. Kay and Kempton reasoned that if language influences cognition, speakers of English would distinguish more strongly between color samples that they call "green" and "blue" than between color samples that fall into the same color category. They posited that this would be true, even if the differences in physical terms were the same in all instances, while for speakers of Tarahumara that would not be the case.

The experimental paradigm consisted in three color samples, and the participants had to decide which one was the most different. As hypothesized, the Tarahumara speakers—lacking a verbal distinction—discriminated among the examples in relation to their physical differences, while the English speakers saw the similarities and differences along their lexical categories. Kay and Kempton reasoned that this could be due to the fact that the strategy of the participants could be that of labeling the samples in the first place, calling each sample “blue” or “green”—a strategy not available to the Tarahumara speakers. The sample that was categorized differently from the other two would be the one chosen as most different, even if the physical differences among the different samples were the same.

To test this explanation, they devised a second experiment. To block that strategy, this time, the three color instances were not presented simultaneously, but through a moving window that allowed the participants to see two of the three samples at the same time: the one on the left and the one in the center, or the one in the center and the one on the right. In each trial, the participant had to determine whether the left example was “greener” than the one in the middle and whether the right example was more “bluish” than the one in the middle. In order to answer which difference was the greatest: the one between the two “greens” or the one between the two “blues.” In so doing, the center instance was labeled both “green” and “blue” in the same trial, so that the discrimination could not be due to its categorization as one of the two. In this setting, the effect found in the first experiment, judging similarity and difference according to lexical categorization found disappeared, and speakers of English performed as the speakers of Tarahumara. Language, then, can be said to be influential in how we perceive similarities and differences.

In order to place this result into a broader perspective, it is useful to keep in mind that something similar happens with other examples of categorical perception, such as consonant phonemes. Any category can be learned, and differences among categories are more easily discriminated than differences within a category (Liberman et al., 1957). In the initial stage, any human baby can learn all possible phonemic categories of human speech and at 4 months can already discriminate among them all. At about 12 months, though, they become attuned just to the phonetic differences that are phonemically significant. It is not that they lose the ability to discriminate those differences completely, but phonemic categorization is stronger and faster (Werker & Tees, 1999). It is language acquisition that drives this categorical perception. While it may be easier to learn a new color than to learn a new phoneme, in both cases what is involved is a restructuring and differentiation of the corresponding space of possibilities.

This comparison also makes it clear that we do not perceive colors only when we have a term to denote them; it is not that without language we would not have color experiences. It is rather that language plays a role in structuring our perceptual space, particularly in memory tasks. Thus, Berinmo speakers from Papua New Guinea exhibit enhanced color discrimination from memory across Berinmo category boundaries, but not across English boundaries, while English speakers show the reverse pattern (Davidoff et al., 1999; Robertson et al., 2000). In general, if two colors are spanned by the same term in a particular language, speakers of that language will judge the two colors to be more similar and will be more likely to confuse them in memory than speakers of a language with a term for each color. These differences develop early in infants and coincide with the acquisition of color terms (Robertson et al., 2004). Further studies have also found the Kay and Kempton (1984) study’s verbal interference effect: crosslinguistic differences in similarity judgments and recognition memory can be affected by direct verbal interference (Philling et al., 2003; Robertson & Davidoff, 2000). This suggests that it is language, itself, that is involved "online" during these tasks. Verbal interference has also been shown to affect speeded color discrimination (Witthoff et al., 2003) and visual search tasks across the English blue/green boundary (Drivonikou et al., 2007; Gilbert et al., 2006).

Further evidence for linguistic influence—even in perceptual color discrimination—has been amassed in the first decade of the 21st century. Using, again, the method of triads devised by Kay and Kempton for their first study (1984), Winnaver and his colleagues have recently compared Russian and English speakers on a simple similarity judgment task, focused on the blue part of the spectrum. It turns out that in Russian two "basic" terms (according to the Berlin & Kay definition) correspond to the English "blue": "golubóy" and "siniy." The former is typically applied to the sky, the latter to the sea. Winower and his colleagues (2007) showed their participants three chips of the blue spectrum: one being the sample, and two options from which to choose the one that's more similar to the sample. They reasoned that if linguistic representations are used to deal with ambiguous color samples—as claimed by critics of relativistic effects—then no language effects should appear in this task, given that it is an objective one that participants can solve with high accuracy. In addition, the task avoided memory, to focus just on perception. Reaction times were measured as an indication of the relative easiness of the task. Finally, the tasks had to be carried out under two conditions: with and without verbal interference. The main hypothesis concerns the affect of the categorical boundary on Russian speakers. If color vocabulary has cognitive effects, performance of Russian speakers should differ from English speakers with regard to perceptual discrimination performance across the boundary. Additionally, verbal interference should affect only Russian speakers. Therefore, it is the cross-category trials—when the participants had to choose between a "goluboy" item and a "siniy" item—in which critical differences were to be expected. Russian speakers should be faster at cross category trials than within-category trials, whereas no difference is expected by English speakers. The results nicely confirmed the predictions: Russian speakers were faster at judging similarity cross-categorially than within-categorially, and verbal interference affected more Russian cross-category than within-category judgments. However, Russian speakers were generally slower than English speakers across all tasks and conditions, an effect that is attributed to less experience in experimental participation, but which clearly requires more attention. Finally, they also introduced a new, indirect measure of the categorical advantage on the grounds that linguistic categories are more likely to play a role in perceptual tasks that are more difficult—just as perfumists and wine experts rely on verbal description for granular sensory discriminations. Thus, they compared similarity judgments of "near colors" and "far colors," in which "near colors" are those that are very similar to each other. As expected, categorical advantage was much greater for "near colors," and it was highly affected by verbal interference. A spatial interference task, was included as a control condition, to make sure the effect was language-specific and not due to a general effect of dual tasking: as expected, it barely affected performance.

A replication of this study was carried out recently with Uruguayan speakers of Spanish, who also distinguish between "celeste" and "azul," as basic color terms along the same way as speakers of Russian (González-Perilli et al., in prep.). They were compared to Spaniards, who only have “azul” as basic (according to the original definition), while they distinguish shades of blue such as “azul celeste” or “azul marino” (light and dark blue). The results matched those of Winover et al.’s study in regard to accuracy (Uruguayan participants had greater difficulty discriminating within category differences of their two terms). The results failed to match those in the Winover study with respect to reaction times, however, in which they found great disparity in both groups. A possible explanation has to do—again—with background in experimental tasks, but a more principled approach, based on a random selection of participants, seems in order. But it could be also the case that the very notion of “basic color term” is problematic in the first place. It might not be an all-or-nothing notion as assumed: even subordinate concepts (such as “azul celeste” for Spaniards) might induce categorical advantage, in some contexts at least.

This suggests that categorical perception for colors is sensitive to learning (Robertson, Pak & Hanley, 2008), linguistic learning in particular. As a matter of fact, it has been observed that categorical perception of color relies on the left hemisphere of the brain, which is the seat of language. Drivonikou et al. (2007) showed their participants 12 colored squares, arranged as a circle: 11 were identical, 1 was different. The task consisted of detecting whether the square of a different color was left or right of the fixation point in the middle. Again, participants were faster when the different color was categorically different, even if chromatic distances were kept constant. Moreover, these differences were noted by the right visual hemifield, which connects to the left hemisphere. But the effect of categorical perception disappeared when participants were instructed to do a simultaneous verbal interference task. In contrast, a version of the experiment in 4–5-month-old infant participants revealed a dominance of the right hemisphere in this case (Franklin et al., 2008).

All of these results together suggest a role of language in categorical perception of color, but it is not clear which one. Opponents of relativistic effects argue that such results just reveal that the participants turn into a verbal task what might have been devised as a nonverbal one. The effect of the interference paradigms—which require the participants to talk while doing the task, thus blocking such a strategic move—would so indicate, instead of supporting the involvement of language in color perception, itself. However, the disappearance of the categorical effect cannot be so easily dismissed: if categorical perception is the consequence of lexical terms for colors—possibly introducing greater precision at the borders—then it is an example of linguistic influence on nonverbal tasks. A recent study further supports such a conclusion (Tan et al., 2008). In this fMRI study, “easy to name” colors were compared to “not easy to name” ones in a standard chromatic discrimination task. In the first case, solving the task also activated lexical search brain areas, not just visual processing ones, as in the second case.

Now we turn to the second recent development, that of the claimed universals in color terminology. Notice that it is an independent issue, even if in the second phase it was viewed as closely linked to the language-independence of color perception. Thus, linguistic differences may have a cognitive effect, even if these differences are not arbitrary and purely conventional, but even if they exhibit a sort of universal pattern in their complexity. A better-supported answer to this question has been made possible by the elaboration of the World Color Survey (Kay & Regier, 2003), and its recent availability through the online World Atlas of Language Structures (Kay & Maffi, 2011). The data were collected *in situ* all over the world, from 110 unwritten languages from nonindustrial societies, from an average sample of 24 native (preferentially monolingual) speakers. Speakers were asked to name each of 330 Munsell color chips, representing 40 gradations of hue at 8 levels of lightness and maximal saturation (chroma), plus 10 black–gray–white chips. They were also asked to indicate the best example for each basic color term. The results, obtained by means of powerful statistical methods, indicate some universal tendencies in color vocabularies, both across the languages of the sample and when compared with the original 1969 sample of written languages of industrialized societies. Emphasis is not so much on a pattern of increasing richness in basic color terminology, but on patterns of central distribution of color terms across the spectrum, by averaging prototypical examples of basic terms across languages (thus, category bounds are not equally emphasized). In this way, spectral areas that more languages single out as prototypical are identified. Interestingly, English color terms—used to define the universal basic color terms—become a little out of the general pattern when placed over this chart, probably due to the fact that most languages included do not have the 11 basic terms of English. Whereas English terms such as blue, green, purple, and brown fall very near prototypical clusters, other terms such as yellow, orange, pink, and red do not correspond to the general pattern. Orange, red, and pink are very spectrally close, so to have all of them in one's vocabulary requires three points of prototypicality. Most languages, however, have only one term for this spectral region, which accordingly places its prototypical point in an intermediate place between the three.

But the most revelatory result concerns a cluster of prototypicality for which there is no English term, in the spectral region between green and blue. This is consistent with the finding that was presented as a counterexample to the pattern of development presented by Berlin and Kay (1969): that a single term may span both green and blue. As a matter of fact, the World color survey reveals that the majority of languages cover green and blue with a single term (Kay & Maffi, 1999). Hence, while there seems to be universal tendencies in color naming, they turn out to be less strong than initially believed, but English terms are not the best guides to them. Moreover, prototypicality is relative to color vocabulary, rather than the other way around; and greater variability is found in category boundaries, which has strong affects on perceptual discrimination. In summary, research on color terms' effects on color cognition reveals a general pattern that will be repeatedly encountered in other areas. Some basic universal cognitive tendencies can be identified (by cross-cultural psychology and linguistic anthropology, and also by developmental and comparative psychology). Linguistic diversity is not absolutely arbitrary and unconstrained, and such diversity is a robust phenomenon that has significant effects on human cognition. As we will see, this is due to the configuration role of culture in human cognition, which occurs in an interactive way. Culture, in its turn, is sustained by individuals and can change.

In this way, the history of color terms' research wonderfully exemplifies the current revitalization of interest in the cognitive influences of language. To put it in the terms of the subtitle of a recent review: "Whorf was half right" (Regier & Kay, 2009), which is a very significant shift from previous dismissive references to Whorf. It remains to be established which part he got right. In Chapter 8, we will discuss which theory of the relationship between language and thought best explains the patterns of new findings, which span much more than color cognition.

4.2 Spatial Terms

Another area that has attracted a lot of research concerns spatial terms and their possible influence on spatial cognition. Languages offer different kinds of terms to talk about space. Levinson (2003) has distinguished between three main areas of spatial cognition which can also be found in language: deixis, topology, and frames of reference. Deixis concerns distance from ego ("this" versus "that") and direction ("coming" versus "going"), and involves radial rather than vector characterizations (it is possible to "come here" from any direction). Topological distinctions concern relations of contact, containment, or propinquity between a "figure" object and a "ground" landmark. Finally, frame of reference provides a way to specify directions—taking ego as polar coordinates—and it is thus most relevant for orientation and navigation.

Bowerman has studied some crosslinguistic differences in topological terms (Bowerman, 1980, 1989, 1996, 2000; Bowerman & Choi, 2003, for a review). Thus, for instance, Choi and Bowerman (1991) compared how English and Korean speakers differ in which spatial relationships they pay attention to. In English, the prepositions "on," "in," and "under" specify the possible relations between an object and a container. Korean, though, lacks a similar specification, but it marks morphologically whether an object is tightly or loosely limited by another (for instance, a finger by a ring versus a picture and the wall), an aspect of the situation which English doesn't specify. Their comparative studies revealed that English and Korean pay different attention to these spatial relations, concluding that acquisition of spatial semantics of the terms of one's language influences children's categorization of spatial relations (Bowerman & Choi, 2003). This does not mean that babies learning English are blind to the tight fit versus loose fit containment relations: all babies are sensitive to this difference by 9 months of age (McDonough et al., 2003). It is rather that—given that the language they learn does not pay attention to such differences—those differences lose cognitive saliency later on.

However, most work in this area has focused on comparing different systems of spatial reference. Three different lexical systems of spatial reference can be distinguished in this regard (Brown, 1994; Levinson, 1996, 1997, 2003; Levinson & Brown, 1994).

- Object-centric or intrinsic framework terms are terms that specify intrinsic positions of landmark objects to extract a direction (often by metaphorical projection of body parts). In English, such terms as "heads" and "tails" (mostly for coins, but extensible to other objects), "front" and "back," or "top" and "bottom" specify a particular part of a landmark that can be used for orientation.

- Egocentric or relative framework terms are indexical terms whose meanings require attention be paid to the position of the speaker. In English, some of the previous terms can be so used, if they specify a part of the speaker (whose corresponding direction, though, moves with the moving subject). Such terms as "in front of," "to the right of," or "behind" are of this kind (as in "it's in front of you," "the seat to my right," or "put it behind the table").
- Allocentric or absolute framework terms are terms that specify absolute positions in space. In English, terms such as north or south are of this kind (as in "travel north" or "it's more to the south").

Most languages combine two or more of these systems. While in English allocentric spatial terms seem to be exceptional, they seem to be the rule in languages such as: Tzeltal (a Mayan language); some Australian aboriginal languages, such as Guugu Yimithirr and Kuuk Thaayorre; and some Asian languages, such as rural Tamil, Longgu, and Arrernte (Levinson & Wilkins, 2006, which is a survey of linguistic diversity in space and movement description; Levinson et al., 2004). Notice that such absolute directions are more arbitrary and abstract than intrinsic or relative, since they cannot be directly perceived; they do not depend upon end points, and orientation requires constant tracking of one's position in a fixed spatial map.

Levinson (1996, 2003) in collaboration with Brown & Levinson (1993, 2000, 2009) studied the Tzeltal linguistic community of Tenejapa. The Tzeltal spatial vocabulary lacks terms corresponding to "left" and "right," but has words corresponding to absolute positions, such as "north" and "east," formed by abstracting from the slope of their land. In this case, absolute position terms correspond to "uphill" (which is south) and "downhill" (which is north), so that they say things like: "Give me the uphill glass," or "the rope is downhillwards the bottle," regardless of current position of the speaker. For orientations corresponding to east and west, the term is the same, corresponding to "across." Tenejapan people are oriented by reference to this framework at all times, while they can also use an intrinsic system of reference, with terms that refer to body parts. The question is whether this preference for an independent frame of reference plays a cognitive influence beyond language.

According to Levinson and Brown, speakers of "allocentric" languages differ from speakers of "egocentric" languages in nonverbal tasks of spatial reasoning, of visual memory, and of gesture. The differences occur in forms related to their different lexical systems, thus providing evidence for a role of language in cognition. Levinson and Brown set several different nonverbal spatial tasks for speakers of these languages, and compared their performance to that of speakers of "intrinsic" and "egocentric" languages (such as Dutch). Tasks required memory of spatial configuration, motion, and path direction. Most famously, they introduced a spatial reversal task in all cases. Tzeltal speakers saw the spatial ordering of four items on a table, for instance, and were asked to remember the spatial ordering of three of them. They had to reconstruct that "same" ordering on another table, which they approached from the opposite side (a 180º turn). The Mayan put the objects in the same allocentric ordering as the original set (what was to the left was again to the left, despite the subject reversal), while Dutch control participants would go for the same egocentric ordering (what was to the left was now to the right). Similarly, in a spatial-reasoning task, participants were observed to find out whether they preferred a transitive ordering of objects in terms of a left to right (egocentric) or a north to south (allocentric) frame of reference. Again, the Dutch used the egocentric and the Tenejapans used the allocentric framework.

Notice that the strategy consists in presenting an ambiguous task, which is why it was described as the "same," as opposed to the same. The instructions could be understood both ways, as has been remarked by defenders of a universal, innate basis for spatial orientation (Li & Gleitman, 2002). Thus, the evidence does not show that any of the participants could not solve the other task. In fact, further research showed that both groups could solve the task both ways (Li et al., 2005). The results, though, do show a different preferential understanding of the task, related to the dominant spatial vocabulary. Similar research was carried out with speakers of Guugu Yiimithirr (Levinson, 2003). Additional evidence came from gesturing: a speaker was filmed gesturing an explanation of a past event twice, in different spatial positions: each time the gestures were done differently in order to point to the west (Haviland, 1993). They also were shown to be "mirror-image blind": pictures that differ in the left/right symmetry axis were viewed as identical—in keeping with their lack of experience with a left/right distinction.

Such a preferential understanding is then connected to the fact that speakers are socially trained to be always spatially oriented, which may be culturally significative given the way they navigate and the importance of this ability in their lives. This is specially clear for Australian aboriginal groups, which have long been known for using sea navigation based on the stars (Hutchins, 1995)—called dead reckoning—given the lack of landmarks in the sea. Similar allocentric orientation is needed for groups navigating deserts, and, perhaps, in a tropical jungle, such as the Yucatan Mayan jungle. In the case of the Tenejapa community—which inhabits a region of precipitous mountain terrain—ritual life also distinguishes between uphill/downhill ceremonials, and no left/right asymmetries are found among their artifacts and houses. Conversely, competence in using cardinal orientation terms in English is not so connected with cultural practices (except maybe by sailors), and they do not exert the same cognitive influence. Lexical terms for space may reflect and stimulate this bent for allocentric orientation—even if the other systems may also be available—because you need to be oriented to speak properly in spatial terms. In summary, Levinson and Brown conclude that such spatial terms form part of a genuinely different way of thinking and talking about space, which makes functional sense in the context of the Tenejapan way of life.

This is not the only example of such an influence. The Kuuk Thaayorre, an aboriginal Australian group, participated in a similar study (Levinson, 2003). They also use cardinal-direction terms (north, south, east, west), instead of terms relative to the speaker or a local point of reference. Again, they did the spatial-reversal task in the same way as the Mayans. This time, a further test of cognitive influence was set. Given that space is also used to ground number or time concepts (more on this in the next sections), Leda Boroditsky studied whether the preference for absolute spatial orientation also influenced these other cognitive areas (Boroditsky & Gaby, 2010). She gave participants a set of pictures showing some kind of temporal process (like an aging man or a growing crocodile) and asked them to arrange the pictures according to temporal order. They tested the participants in two separate places, differently positioned according to cardinal orientation. Previous studies had shown that time direction in English and Hebrew speakers is conceived in terms of writing direction: left to right for English, right to left for Hebrews (Fuhrman & Boroditsky, 2010). Given that speakers of Kuuk-Thaayorre lack terms for left and right, they did not arrange cards from left to right, more often than from right to left. The pattern of their responses was rather east to west orientation (metaphorically grounded in the daily process of the sun): if they were placed facing south, they placed the cards left to right, but if they were placed facing north, they placed the cards right to left. Thus, speakers of Kuuk Thaayorre exhibit a greater navigational ability and spatial knowledge than speakers of languages with relative frames of reference. They keep track of where they are, even in unfamiliar landscapes or inside unfamiliar buildings, because otherwise they could not talk about space. A parallel research has also been tried with the Tzeltal (Brown, submitted).

The interest of allocentric spatial frameworks, then, amounts to challenging the previous assumption that egocentric orientation was universal in humans (Brown & Levinson, 2009; Levinson, 2003). According to the nativistic view, egocentric, left/right orientation would be universal and grounded in the egocentricity of our visual system, in a parallel argument to Rosch's for focal colors. Viewing linguistic and cognitive diversity as constitutive, on the contrary, rather than the result of a diversification process out of a universal, biologically structured, initial state, raises the question of how cognitive diversity comes about—a question that entails a renewed attention to the developmental process and the possible structuring role of culture in it (Tomasello, 1999). Thus, assuming a common human initial state at birth, does it involve a preference for some special conceptualization of experience (for instance, for an egocentric framework over an allocentric one), which has to be overcome in development by the cultural preference one encounters? If that were the case, the further question of how such cultural variation could have emerged in the first place given such a spontaneous initial bias should also be addressed. However, it would be expected that children would need more time to learn society's special conceptualization of experience than children learning the linguistic terms that match such an initial preferential grasp. Another possibility involves the equipotentiality of all cognitive variations, which would go hand in hand with early learning of the linguistic pattern in one's community, as a way to develop a preferential understanding. Such equipotentiality can be conceived of in terms of a problematic initial blank slate (Pinker, 2004) or, just as it seems to happen in phonological development, in terms of all of the different systems already being implicitly available from scratch, with linguistic development pruning them by reinforcing just those relevant in cultural practice.

Which one of these alternative is the right one is an empirical question of sorts, but the answer may be variable and diverse: it may be that all of these options are valid of some concepts. In the case of spatial orientation, in particular, there is evidence of a mammal-wide sensitivity to geometric properties of space (Section 6.3.3), playing a strong role in initial spatial orientation explain. On the other hand, cultural cognitive differences can be of differing complexity. In the current case, allocentric frameworks are more complex (they include four topological parameters) than egocentric ones (three topological parameters: ego, object, and target); and the latter are more complex than an intrinsic, object-centered one (just two parameters: target and landmark) (Levinson, 1996). In other words, the allocentric one should be more difficult to learn than the other ones. However, infants seem to be early attuned to the semantics of the spatial terms they first learn (Bowerman, 1996, 2000). A longitudinal study of Tzeltal infants (Brown & Levinson, 2000) indicated that they grasp the basic semantic oppositions of their absolute frame of reference by 3;6; they can understand intructions in novel spatial tasks by 4 years old, and are able to use them systematically in successfully producing descriptions between 5;8 to 7;8 years of age (according to Piaget & Inhelder, 1956, mastering the left/right difference takes longer). Brown and Levinson used an informal communicative task—a "space game"—in which a participant describes a spatial scene depicted in a picture to another, who is to reproduce it from the description with toys. Similar ages have been found for children learning other absolute reference languages (Mishra, Dasen & Niraula, 2003; Wassman & Dasen, 1998), but the task elicits a variety of spatial terms, not just absolute ones, given that the Tzeltal also use an intrinsic reference framework, and deictic and topological terms as well. Therefore, in a posterior study (Brown & Levinson, 2009), they focused, in particular, on the question of whether the other framework systems also show up in early infancy, to assess whether the other framework systems provide some bootstrapping to help the child eventually grasp the more abstract and complex absolute system.

A typical description, produced by a participant, in this task, may go like this: "There's a tree standing there right *in the middle* (topological). Here comes *to our front* (deictic, intrinsic) a little drinking trough. A little bit *far away* (deictic) a cow is *coming* (deictic) with his butt to *sunset* (absolute). *Uphill of the tree* (intrinsic) comes another one ..." Another participant then has to reproduce the setting of animals described. Remarkably, absolute terms are mostly used by 5–7 year olds, while older participants show an increasing use of landmarks, which can be interpreted in terms of the increasing flexibility required for greater detail and precision (Brown & Levinson, 2009). These results, in conjunction with evidence of absolute spatial orientation in nonhuman primates (Section 6.2.4) and with developmental evidence of how landmark use for orientation is linked to linguistic description and increased flexibility (Section 6.3.3), allow Levinson and Brown to conclude that there exists an initial preference for an absolute spatial framework in humans. This preference is shared with the rest of primates, even if they do not show the degree of abstraction and arbitrariness involved in cardinal points and recognition of fixed astronomical points of reference—an issue that will be discussed in Chapter 8.

4.3 Numerals, Geometry, and Mathematical Cognition

Numbers, or rather, numerals, have been another outstanding area of research, combining crosslinguistic, developmental, and animal studies. Again, in this chapter we focus on crosslinguistic studies and their cognitive effects. Numbers are abstract entities, which cannot be grasped directly, but must be grasped through a symbolic means of representation. Numerals are the terms the language offers to denote the numbers; for arithmetics, other, more specific symbols may be required (functions, operations), in addition to the numerical representation. Languages also differ in their numeral systems, so the question arises: to what extent do these differences matter for mathematic competence?

In fact, mathematical competence seems to be a matter that goes beyond linguistic competence. In Western culture, it requires a specific kind of alphabetization. But what about the basic numeric concepts: set, successor, and cardinality, for example? Are they language-decoupled? Or do they depend upon a way to represent numerals, for instance?

There is a broad consensus that some numerical concepts are independent of language (Dehaene, 1997; Lipton & Spelke, 2003). There is evidence that we share some basic notions with animals, such as “more or less” and “numerosity,” because prelinguistic infants and some nonhuman animals can discriminate the numerosity of small groups of objects and can recognize that one is larger or smaller than another (Starkey et al., 1990). They can also discriminate between sequences of sounds (Starkey et al., 1990) and doll swings (Wynn, 1996), according to their respective numerosities (for nonhuman primate capabilities, see Section 6.3.2). It has also been claimed that infants can perform the addition and subtraction of simple numbers (Wynn, 1992), for quantities up to three or four. It has been disputed, though, that this can be done without strictly numerical concepts (Leslie et al., 2007).

However, when it comes to exact numerical concepts larger than four, it is clear that they are acquired through language. It is a prominent example of the concepts that depend on language, at least at two levels: developmentally, in that the term comes first and then the child has to somehow come to understand its meaning; and processually, given the evidence that their linguistic representation is involved in calculations and arithmetic tasks (Spelke & Tsivkin, 2001). The authors of this study found that bilingual subjects trained on new number facts in one language, recalled those facts faster and more reliably when tested in that language, than when tested in their other language.

As with color, though, languages may vary a lot in their numbering systems. Some languages may have a very short numeral repertoire, as in “one-two-many” (Greenberg, 1978), while others avail themselves a generative system that guarantees a numeral for each possible number, such as that found in Western languages. Peter Gordon has focused on one of the “one-two-many” languages: the Pirahä, an Amazonian language spoken by a tribe of hunter-gatherers (Gordon, 2004). Pirahä has become famous for the claim that it is not recursive (Everett, 2005), a counterexample that could compromise Chomskian linguistics. Recursion is the defining feature of natural languages according to Chomsky and the proposed key to understanding their evolution (Hauser, Chomsky & Fitch, 2002). The evidence is still contentious (van der Hulst, 2010), particularly in regards to sentential embedding. As we will see in the next chapter in relation to subjunctive conditionals and counterfactual thinking, and in Section 6.3 in relation to sentential complements in false-belief attribution, it is well known that some languages, like Chinese, do not explicitly mark sentential embedding, but juxtapose sentences. While Pirahä could be like Chinese as far as sentence embedding is concerned, the fact that it lacks a productive number system, which constitutes another example of a recursive structure, reinforces the case for categorizing it as a nonrecursive language.

The question is whether Pirahä speakers—having terms just for one, two, and many—are somehow impaired in arithmetic functions, such as counting, addition, or subtraction. According to Gordon, they are unable reliably to tell the difference between four and five objects placed in a row. In other words, Pirahä speakers perform like nonverbal infants and nonenculturated primates (see Section 6.3.2), lacking a symbolic means for counting. The procedure Gordon used was a sort of imitation game: he laid out a random number of familiar objects, like sticks and nuts, in a row, and the participant (there were seven of them), was supposed to do the same. For one, two, and three objects, the Pirahäs' row matched Gordon's sample. But when the number of objects was from 4 to 10, Pirahäs just approximated the number, with increasing deviation as the row grew longer. In another task, participants were shown several boxes, with different quantities of fishes depicted on top. Seconds later, they failed to take this difference into account in order to remember which box kept a hidden object. Similarly for rhymic tapping: they could imitate tapping on the floor of up to three taps, they failed to mimic strings of four or five taps. Gordon observes that the Pirahä do not need to count in daily life, and concludes that this evidence demonstrates that numerical concepts beyond three are acquired through the acquisition of the corresponding numerals.

Similar results were obtained by Pierre Pica with speakers of Mundurukú (Pica et al., 2004), another Amazonian language which lacks numerals beyond five, even though Pica and collaborators disagree of Gordon's relativistic conclusion. While speakers of Mundurukú are able to compare and add large approximate numbers beyond five, they fail exact arithmetic with numbers over 4 or 5. Again, this evidence is interpreted in terms of a dual system of numerical competence: a basic nonverbal system of number approximation, and a language-based counting system of exact number and artihmetic. However, it again remains to be established what the precise role language is in the understanding of numbers. This must be determined in order to know if the language-based system is not a real improvement on numerical cognition (as Pica thinks), or if abstract understanding of concepts as language-dependent is a relativist effect (as Gordon affirms). The question is: which relationship holds between the two systems, once the recursive number system made possible by numerals is in place? Is it a complementary one? Or is it rather a transformative one, given that exact number understanding opens up a whole new world of cognitive possibilities (Bloom, 2000; Wiese, 2003)?

At least part of the answer to this latter question will depend on how number understanding is developed. In other words, what does it take to grasp a recursive, potentially infinite system, like the number one? The grounding problem for concepts is especially difficult for the most abstract concepts, like numbers (or temporal concepts, for that matter). Implicit understanding is manifiested in the practice of counting, and it is this practice that it is made possible by a symbol system that generates numerals. Tthis practice also involves an implicit understanding of succession or cardinality, for instance. The theory of "language as modular interphase" suggests, in this case, that language works by providing a means for integrating various nonverbal representations to create a concept of a large, exact number (Carey, 1998; Dehaene et al., 1999). However, it is not clear how to jump from numerosity to exact number. It is not even clear if the cognitive effect relies on verbal numerals, or if it also requires graphical numbers, some for more permanent, written representation. The graphical, written form is also absent in Pirahä and Mundurukú, even for the numbers they are able to manage—which accords with a universal, basic understanding.

A hint to the answer to this question can be found in Pica's observation that numeral expressions in Mundurukú are long, often having as many syllables as their corresponding quantity. The words for 3 and 4 are polymorphemic: ebapüg = 2 + 1, ebadipdip = 2 + 1 + 1, where "eba" means "your two arms." This suggests the rudiment of a way to name quantities in a systematic way, by establishing a correspondence between quantity and syllabic structure. Whereas it is not a feasible procedure in general, it makes clear that counting is the required ability to master first. Pica suggests that other languages of the Mundurukú family use a base-2 system of numerals—in which the corresponding terms of "eba" get repeated—but even in that case, the most revelatory aspect is that it suggests a basic form of counting that is related to body parts. Similarly, the expression for five corresponds to "a hand" or a "handful." There is a connection worth taking into account in this regard: a case reported by Karmiloff-Smith (1998) of an association of dyscalculia with dactilar agnosia. This suggests that we are introduced to counting with the fingers, so that impairment of finger sensitivity may impair the internalized bodily behavior developed to master numbers. While such social practices of counting may have a developmental influence on the brain, dyscalculia may also depend on the impairment of the more basic understanding of numerosities (Butterworth et al., 2011).

This required emphasis on counting as the key ability to go from numerosity and approximate quantity to exact number prompts us to refer in this context to Saxe's (1982) study of Oksapmin, as a sort of middle, transitional case. Oksapmin is a Papua New Guinea linguistic community, which at the time of study was undergoing a cultural change related to the introduction of money. This made counting practices more relevant, an required an amplification of the numeric system to deal with the new arithmetic operations involved in the use of money. According to Saxe, the traditional Oksapmin number system for counting is also finite and based on the body, but this time 27 consecutive numerals are available. As a matter of fact, the terms constitute an order sequence of body parts, starting with the thumb on one hand, and proceeding through the upper periphery of the body and then down to the other side. No other symbolic representation is available: number 14 corresponds to the nose, and the forearm is 7. This numeric system was used for counting and measuring. However, it was not put to traditional arithmetic use, and no term exists for mathematical concepts of division, or for rational and irrational numbers.

During the seventies, money was introduced to the Oksapmin community, through paid work and commerce. This created a denomination problem, given the shortness of the numerical system. The adaptation that took place to deal with the new social need for referring to currency was a base-20 system, that recursively uses the basic terms in succesive cycles, as required. Such a change went hand with hand with a reorganization of arithmetic thought: beginning with the new coin counting practices in commerce, for instance, arithmetic functions—such as addition and substraction—later emerged. The culmination was the emergence of mental calculus—the ability to count without physical support (fingers in our case; upper body parts in the Oksapmin's case). Saxe (1982) found evidence of this cognitive transformation in the making, by comparing four groups of subjects with respect to addition and subtraction problems. The groups included: men who had owned a trade store for at least 2 years; men who had returned from a period of work at a plantation but did not own a trade store; young adults who had not been to a plantation, and, therefore, had no money experience; and older adults who had only a cursory level of experience with the money economy. He could witness the process by which practice with money pushes for a recursive open-ended numerical system that is increasingly used for mental calculation. Addition problems became solved in that way by the most experienced subjects. A procedure of starting with the first figure and then following the bodily series for the other figure was used by less experienced subjects. This followed more simple strategies—like the double enumeration one—in which each figure, which corresponds to a numeral-body part, is mapped onto the corresponding body part to begin with, and then a procedure for establishing correspondence is tried. In general, while all groups could do addition with coins, subtraction with coins was difficult for the groups not habituated to money. Without coins, performance of all groups differed in proficiency, in a rank that went from nonceiling competence for experienced traders, to null for nonexperienced older adults. Nonexperienced adults, though, performed at a higher than chance level, an indication of a greater facility for learning.

In summary, Oksapmin exemplifies the central idea of the "conceptual metaphor" theory: that understanding of abstract concepts is achieved in terms of more concrete ones. Most importantly, these concrete ones are "image-schemas" and spatial egocentric concepts based on the body (Núñez, 2008). While these basic schemas are thought to be primitive, there are many of them. Languages freely choose from this pool of conceptual resources in a rather arbitrary manner, which, however, has strong cognitive effects. In other words, numerals do not create number understanding out of nothing. When numerals are encountered by children in their process of language acquisition, they make sense of them in terms of one of the basic body schemas available that the group is already using to make sense of numbers. In this way, it can be viewed as scaffolding for individual cognitive development. Numerical problems can only be dealt with to a certain extent in such a system. Purely mental processes result from interiorization of such practices, which also limits the scope of tractable arithmetic problems. Change in these systems is also possible by standard processes of cultural innovation, but what is kept constant is the bodily grounding of conceptual understanding.

Further support for this metaphorical understanding of abstract concepts—such as numbers—on concrete spatial schemas, can be found in further research on the Mundurukú (Dehaene et al., 2008), even if the researchers do not fully apreciate this connection. As a matter of fact, the mapping of numbers onto space is an important component of formal mathematics, including measurement in geometry and Cartesian coordinates in algebra, as a couple of examples. However, formal mathematical mapping is a cultural invention that took place in Western history, and it is taught at schools. This raises the question of whether there exists some innate preferences for such a projection. As a matter of fact, developmental evidence indicates that a striking shift in how children conceive of number mapping onto space takes place around the age of six, when scholar arithmetic alphabetization begins (Booth & Siegler, 2006). The standard linear projection of numbers on the scale, which means that each unit spans the same segment, substitutes an initial logarithmic projection, in which smaller numbers take up more space: in a 1–100 segment, 10 may be placed in the middle, for instance. Given their very limited number system, the Mundurukú were tested using numerosities, rather than numerical symbols. Under the same conditions, they were also able to establish a systematic mapping of differing numerosities, and this mapping was also logarithmic, as was the case with Western preschoolers. Given that the instructions required the mapping to go from left to right on the horizontal axis, though, it remains to be established whether this is the most natural mapping for the Mundurukú, or whether they could equally understand right to left, or vertical mappings. However, Dehaene concludes that their study proves that numerosity understanding, shown to be present in preverbal children and even nonhuman primates (see Section 6.2.2), involves also this logarithmic projection onto space. He also insists that numeral acquisition is not enough to account for such a shift in Western children's conceptions of mapping as linear, given that Mundurukú numerals do not induce such a change in Mundurukú adults. That shift in Western children's conceptions is clearly—since linear mapping is taught at school—a part of mathematical instruction. As the Oksapmin example reveals, a traditional symbol system may undergo change to deal with new problems. The question is whether linear mapping requires a conception of numbers that is connected to counting, measurement, and invariance.

A similar "mathematization of space" is found in geometry. Again, the Mundurukú have been studied in this regard (Dehaene et al., 2006), in order to show a universal, innate bias for geometrical understanding, quite apart from spoken language and cultural practices. This time, a multiple-choice task was used to probe implicit understanding of geometrical concepts. Each trial, six items were presented and the participants were asked to find the "the weird" or "the ugly" one: five items instantiated geometrical concepts (were circles, let's say), and one was different. Notice that six items were used to drop the chance level, to make it more clear whether a pattern was significant (chance level was at 28%; an avarage of correct responses over this level was significant). Concepts probed included all euclidean notions (straight line, curve, alignment, parallel lines, right angle), geometrical figures (quadrilateral, trapezoid, parallelogram, rectangle, square, triangle, circle), symmetries, metric properties, and geometrical transformations. Participants performed well above chance level in 39 out of 45 slides, with no influence of age, schooling, or bilingualism. The most difficult tasks were those that required a mental transformation, such as mirror symmetries. To make sure that performance was based on geometrical understanding—instead of surface perceptive properties—a complementary map test was performed, to ensure the Mundurukú could use geometrical information for orientation. When landmark information was also available, Mundurukú adults took more advantage of it than children.

Mundurukú's performance was compared to North American adults and 7-year-old children. The latter were similar to Mundurukú participants, while adults performed significantly better. However, it is not so clear that these results support the grand conclusion that geometrical knowledge is innate. While it is well-known that most mammals take advantage of simple geometrical information for orientation and navigation (as we will consider in Section 6.3.2, to consider how language plays a crucial role in the integration of geometrical with landmark information for more flexible orientation), geometrical knowledge takes time to develop, and schooling may be a further factor. As a matter of fact, North American adults' higher performance supports some effect of language or culture. This would have been more dramatic if reaction times were also compared. Mundurukú participants took between 20 and 30 s to respond; astonishingly, reaction times for North American participants were not provided.

This time, researchers mention the fact that—whereas the Mundurukú language has few words dedicated to geometrical or spatial concepts—a variety of metaphors are spontaneously used. Thus, for instance, "iroyruy'at" means curved figure or circle. "Yabi" is an expression that literally means "the mount of the round thing" and stands for dot, point, beginning, and end. "Kadi," which literally means bank of a river, stands for side. "Ipidase," which means "on the mouth of the earth," stands for center, middle, and half (the earth occupies the middle layer in Mundurukú cosmology). "Ipidasese" means quarter. They also have spatial propositions for several spatial relations, including left/right, near/far, and front/behind. However, again Dehaene and colleagues do not see this as relevant to the task at hand. It seems that this evidence concerning geometric understanding also supports the view that a basic implicit understanding of space and spatial relations—which may be shared with other species and constitutes a first stage of development (even if conceiving of it as modular is problematic; Newcombe, 2005)—is transformed by language, symbolism, and cultural practices, giving rise to cognitive differences between linguistic communities.

Finally, whereas attention to simpler linguistic systems, such as that of numerals, may reveal more dramatic effects, differences between languages in numerical terms can also be found, even among languages with open-ended numerical systems, which also have been shown to give rise to differences in arithmetic capabilities. In English, for instance, the set of primitive numerals to be independently learned are the initial 10 figures, plus the special 11 and 12, and the irregulars 13–19; the decade numerals are irregular as well, and then a limited bunch of terms for the big figures are needed (hundred, thousand, million, and billion). This equals more than 30 different terms in total. In Chinese, on the contrary, the system is perfectly regular: the 11 initial figures are enough to generate all numerals, together with terms for 100; 1,000; and 10,000. Thus, 11 in Chinese is literally "ten and one." Interestingly, English children have difficulty learning how to count in the teen range, while Chinese children do not (Miller & Stigler, 1987; Miller et al., 2000). Italian children, with a linguistic numeral system similar to English, exhibit similar difficulties to speakers of English (Agnoli & Zhu, 1989).

In summary, in this chapter we have found many examples of differential lexical influences on cognitive capacities. Some of this research has focused on the hypothesis that categorical borders of concepts are linguistically established through socio-communicative practice. Some of it has focused on the fact that language terms draw attention to some dimensions of experience, and languages differ in which dimension they highlight. Still other research has underlined the fact that abstract concept understanding involves some kind of metaphorical projection on spatial and bodily experience, which also can be diverse from language to language. The relationship between these language-induced cognitive biases and the basic, primitive, innate cognitive forms of understanding reality still needs to be clarified. In particular, the question to be resolved in order to assess which theoretical account from the continuum gets more support, turns on whether the "linguistic mode" of cognition is a sort of parallel, alternative way to think that supplements a basic imagistic one, or if they are somehow intertwined. This question is also connected to the question of the nature of the basic cognitive architecture of the mind.

5 Language as Lens: Morphosyntactic Differences

In addition to comparing lexico-semantic systems of different languages, another way to look for relativistic effects is by considering morphosyntactic differences between languages. While Chomskian linguistics has emphasized linguistic universals in human natural languages, linguistic diversity is still abundant (Pinker, 1994; even he offers many examples of it), and the question is whether these differences may also have cognitive effects on how the world is conceived, where categorical limits are placed, and which aspects of experience are noticed as most relevant. Do speakers of different languages think differently about the world? Do they partition the world in different ways? Do they pay attention to different relational properties or different processual aspects?

Just to give you a flavor of what morphosyntactic diversity amounts to, notice that in Indonesian, tense is not marked. In Russian, tense and gender are marked in the verb. In Chinese, indicating when the event ocurred is optional and has to be separately specified. In Spanish, aspect is also required (the speaker is forced to specify whether the action was completed or not). In German, past expression can choose between two auxiliaries (corresponding to "be" and "have"). In Turkish, speakers are required, when retelling an event, to specify whether they actually witnessed it (Aksu-Koç & Slobin, 1986). Not surprisingly, there is evidence that speakers of Turkish also remember events according to whether they witnessed them, while English speakers show no such habit. Diversity also concerns noun phrases, with a convoluted set of possibilities for marking gender: with several possibilities available in addition to masculine and feminine forms depending on language, including no gender marking, such as in English). In all of these cases, corresponding specification is done by a compulsory inflectional morpheme, required for grammaticality but some languages mark it by sentence position. These differences may also interact, as when tense and aspect need to be combined with mode (indicative, subjunctive, imperative). And so on and so forth.

Although few studies examined these differences, their conclusions were similar (Lucy, 1996). Whorf himself belongs to the tradition of linguistic anthropology (Boas, 1911; Sapir, 1924), which was speculative in this regard, being under the influence of Romanticist belief in a irreducible human diversity. Whorf was the first to look for empirical evidence in this regard, by selecting morphosyntactic differences between two languages and looking for evidence of cognitive differences in the cultural beliefs and practices of the corresponding linguistic communities. However, no proper individualistic experimental or quasi-experimental research was carried out. Thus, for instance, Whorf notices that the Hopi and the English express time differently: English is thought to objectify time periods (a day, a month), while Hopi treats these cycles

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as recurrent processes (they are expressed adverbially, rather than as nouns). He also notices that English speakers' conception of time as a continuous, homogeneous, formless substance that can be measured, divided into exact parts, and counted (three days), which differs from the recurrent, cyclic conception of time of Hopi speakers (which blocks counting of temporal units). He concludes that the conceptions of time of these groups differ because their respective ways of talking about time is different (Lucy, 1992b, 1996; Whorf, 1956). Clearly, such a conclusion requires an improved sort of empirical evidence.

In this chapter, I will review some of the most relevant research from this standpoint, following a temporal order. Differences in subjunctive conditionals, grammatical number marking, the object/substance distinction, the semantics of movement and action, gender marking, and time will all be considered in this chapter.

5.1 Subjunctive Conditionals and Counterfactual Understanding

A pioneering study of neo-Whorfian inspiration was carried out by Bloom (1981). She focused on the subjunctive, a verbal form missing in Chinese, which relies on the indicative. Since subjunctive conditional constructions are crucial for counterfactual reasoning ("had you arrived on time, the accident would not have happened"), she hypothesized that Chinese speakers would have a difficult time understanding texts with counterfactuals. She prepared narratives in English, and had them translated into Chinese. She then asked a group of English speakers and a group of Chinese speakers to answer a series of questions on what would have happened if some of the events of the narrative had not occurred or had occurred differently. The English speakers gave better answers, a result that Bloom interpreted as evidence of the relevance of the structural difference between the languages. Au (1983) challenged that interpretation, on the grounds that the translation of the narratives into Chinese was defective; the lower performance of the Chinese speakers could be attributed to the artificiality of the translation, rather than to an effect of the lack of counterfactual reasoning due to the absense of the subjunctive. In addition, Liu (1985) provided evidence that Chinese speakers can reason counterfactually, just as they can also understand hypotheticals.

It seems that the Chinese grammatical mechanism for indicating mode and subordinated conditionalization could be different in this case from subjunctive, using instead a form of juxtaposition. So, this illustrates the possibility that what seems to be a *prima facie* linguistic difference may turn out to be a difference in syntactic mechanism, not a full-blown difference. Bloom's study also was found wanting for using a variety of grammatical structures (Lucy, 1996). However, it has also been remarked (Hunt & Agnoli, 1991) that this syntactic difference in the way subordination is syntactically marked may give rise to a processual difference. This is true because one language may make hypotheticals and counterfactuals more clearly recognizable and salient than the other, thus facilitating the process of counterfactual understanding, along the lines of the "thinking for speaking" hypothesis. In the same vein, differences in the discursive use of counterfactuals may also be a significant difference in itself.

At any rate, this debate helps to clarify the methodological requirements needed to get relevant empirical evidence. Thus, such research should be comparative, it should deal with a central grammatical category, it should probe the cognitive performance of individual speakers through nonverbal tasks, and it should ideally cohere with socially salient cognitive patterns (Lucy, 1992b).

5.2 Grammatical Number Marking and the Object/Substance Distinction

Languages also differ in the way they categorize individuals, understood here as entities and substances: in how they distinguish between "individual names" and "mass names." In English, for instance, if an individual noun applies to more than one object, the term has to be in plural and may be preceded by a numeral adjective: "two tables." However, if it is a substance, it cannot be a numeral added in front of the plural morpheme ("two sands"); instead, it needs a specifier ("two heaps of sand," "a gallon of milk"). Thus, morphological marking of number is restricted just to nouns of countable individuals. In Yucatec Maya—a Mayan language spoken in the Yucatan peninsula of Mexico—on the other hand, only animate entities are considered individuals that can be counted (and thus be in plural and numbered). Inanimate entities (for us) are grammatically treated by Mayan as substances; they also need a specifier and cannot be in plural, as proper substances. Thus, a candle is "un-tz'üt kib": literally, "a long and thin wax," which is treated as a substance (Lucy, 1992). In other words, the "shape bias", the preference to categorize in terms of similar form, rather than the material objects are made of, in word meaning just applies to nouns for animate entities in this linguistic community. The rest are preferentially categorized in terms of material.

Thus, English and Yucatec grammars treat terms of inanimate entities in very different ways: as individual items (English) and as substances (Yucatec). This provides an excellent setting in which to raise the question of whether these linguistic differences give rise to cognitive differences between speakers of both languages (it turns out that it is not the only remarkable difference that has been studied), even when they are not talking. Lucy contends that his studies support the conclusion that this is indeed the case: that this linguistic difference is of cognitive import.

On the one hand, Lucy (1992) prepared a version of the Kay and Kempton (1984) triadic paradigm for a judgment-of-similarity task, asking speakers to choose which object is more different. Lucy presented a triad of pictures of inanimate entities: a sample, and two options, one sharing the same form, the other sharing the same material, with the sample. The results showed that Mayan adults prefer same material over same form in their performance of the task, while English adults show the reverse preference. Lucy also presented a picture-recall task to see whether English and Mayan speakers differed in the recall of the number of items in a picture: they were shown a picture, and later they were shown a highly similar one, but for some changes in the quantities of animate and inanimate objects, and also of substances (like mud puddles). While English speakers paid equal attention to changes in both animate and inanimate objects, but overlooked changes in substances, Mayan speakers just noticed changes in animate objects, treating inanimate objects as substances (Lucy, 1997).

Lucy (1992) also contended that all languages have to establish this ontological distinction between individuals and substances. Following this suggestion, Imai and Gentner (1997) raised the question of the interaction between cognitive and linguistic development taking Japanese as contrasting language, which establishes the boundary in a still another way. More precisely, they set out to determine whether there is a preferential, pre-linguistic conceptualization of inanimate objects (as individual objects or as substances) that might be universal. The sort of linguistic influences shown by Lucy regarding how Maya speakers set the boundary between individuals and substances, for instance, could either be in tune with this basic developmental tendency or have to overcome it. Thus, a basic tendency, if it exists, could make it easier or more difficult for a speaker to acquire a cultural or linguistic trait. Conversely, it could be claimed (following Quine, 1962) that the distinction between individuals and substances is itself language-relative in the sense that, given the logical problem of fixing the reference of linguistic terms, the grammatical cues are all children can count on. In other words, by considering the curse of semantic development and the patterns of meaning projection in children, one can gain a glimpse into which categorical distinctions are available before language—as a sort of spontaneous, innate bias—and which ones are language-dependent.

Imai and Gentner (1997) compared the patterns of lexical development of North American and Japanese children with respect to nouns referring to individual objects and substances. In Japanese, the difference between "countable" and "mass" nouns is not marked. This means new speakers of Japanese cannot rely on numeral adjectives, pluralization, or specifiers to notice the ontological difference between their references, whereas in English and Mayan, new speakers have these sort of cues. Following the suggestion of Soja et al. (1991), Imai and Gentner reasoned that if the ontological distinction between individuals and substances was language-independent, grounded in some kind of perceptual differentiation, North American and Japanese children would develop it at the same time; whereas if they would need to rely on linguistic cues to grasp this ontic distinction, North American children would be faster. They also considered the possibility of a late effect of language: after a similar initial learning period, differential sensitivity to the difference between individuals and substances could be greater in speakers of English, which would show up in different patterns of meaning projections.

Using three different types of items—substances, simple objects, and complex objects, to control for form or shape, material, and complexity—they investigated their participants' patterns of meaning projection. After being shown a sample and being given a term for it, they had to say which of the three alternatives—similar to the sample in form, material, and complexity—could be another instance of the same term. The results indicated that both linguistic groups distinguished complex objects and substances in a similar way at the same age (2 years old), while they differed for simple objects: North Americans preferred meaning projection by form, the shape bias, at an earlier age than Japanese participants did. Imai and Gentner contended that while infants may distinguish between objects and substances before language learning, the way the limit between these categories is established may be relative to the language one learns. In other words, grammatical aspects of our language may influence our ontology.

Imai and Gentner's work naturally raised the corresponding question with regard to Yucatec: is the preference of Yucatec speakers for viewing inanimate objects as substances related to their language? Or is there a basic, pre-linguistic preference that language somehow molds and tailors? In other words, when is it that the Yucatec preference for the material composition of stable objects over their shape develops? Before or after they learn their language? And if it is after, what preference do they exhibit before? Lucy returned to the Yucatan peninsula, but this time compared not just adult speakers of English and Yucatec but also children, in a match to sample similarity judgment task (Lucy, 2005; Lucy & Gaskins, 2003). For the task, the inanimate object sample could be matched by shape or by material. Again, the adult speakers of English showed a bias for shape (they only choose the option made of the same material as the sample an average of 23% of times), while Yucatec speakers showed a material bias (61% times they made material choices). However, when 7-year-old Yucatec children were considered, a similar early bias as that of English speakers toward shape was found (infants only made 12% of material choices). Nine-year-olds showed an in-between, intermediate stage (choosing material or shape about an equal number of times).

Lucy concludes that "seven-year-olds show clear sensitivity to referent type independently of language group membership. Here we see they prefer shape as a basis of classification with stable objects; in related experiments, with malleable objects, they prefer material as a basis of classification. Nine-year-olds show differential sensitivity to referent type in line with their language. This suggests that language categories increase in their importance for cognition between ages seven and nine" (Lucy, 2005, p. 306). Whereas the interpretation of the 9-year-olds's performance is overstated (justified in hindsight), the troubling result here for Lucy is that it takes so long for children to project meanings the same way as adults. On the other hand, in coherence with Imai and Gentner, Lucy acknowledges a spontaneous preference for a shape bias, but claims that this preference is not enough to resolve the question of whether the semantic extensions depend on linguistic practice. It also raises the question of why, if the spontaneous bias is toward shape, "material" languages and thinkers also exist (see also the parallel discussion of spontaneous communicative gestures in deaf children, in Section 6.1). An alternative explanation would be to rethink the nature of this basic bias, viewing it as a sensorimotor dynamic pattern, rather than as a full-blown concept. Discussion of these basic questions is deferred to Chapter 8.

5.3 The Semantics of Movement and Action

Attention to crosslinguistic differences in verbs of motion and action was prompted by Talmy's work (1975, 2000). He observed that languages differ in which semantic elements motion/action verbs code for. Regarding motion, he distinguished a set of parameters that characterize any motion event: the moving figure, the stable background, the path the moving figure travels, the manner of the motion, or even the shape of the moving figure. Languages differ in which dimensions their verbs lexicalize, and which dimensions are morphologically marked or demand a further adverbial or phrasal specification. Thus, whereas English verbs are supposed to lexicalize the manner of the motion ("climb," "walk," "run"), Spanish verbs are supposed to lexicalize also the path ("subir," which translates as "to go up"). The example, though, indicates that path is expressed in English with prepositions or adverbs that modify the lexical core (e.g., in, out, up, down, or off), rather than not indicating it at all. It could also be remarked that English verbs can be of two etymological origins, with many of them sharing the same pattern as Spanish verbs, given their common Latin origin. Thus, in English you can have both "come in" and "enter." In other words, crosslinguistic comparison should not be restricted just to different lexical patterns, but also to how events are linguistically coded: whether lexically or with prepositional phrases or adverbially, in order to assess whether they code the same dimension of events.

On these grounds, it is not surprising that it has been difficult to find relativistic effects of these crosslinguistic differences. Following the "thinking for speaking" hypothesis, it was hypothesized that speakers of Spanish should pay more attention than English speakers to the path in a motion event, while the latter should pay more attention than the former to the manner of motion, on the mistaken assumption that lexical differences would give rise to cognitive differences in motion events processing (Malt et al., 2003; Slobin, 1996), without realizing that Spanish verbs also lexicalize manner. In fact, it was assumed that "Spanish speakers encode path in the verb and tend to omit manner considerations" (Malt et al., 2003, p. 94), which is plainly wrong. Consider verbs of human motion events: caminar (walk), correr (run), saltar (jump), pasear (stroll), deslizarse (slip), and volar (fly). Manner can also be expressed with a prepositional phrase: ir de puntillas (sneak), venir corriendo (go running), or tocar a la puerta (knocking the door). What is true of Spanish is that some verbs are rather semantically inspecific and can be used in many contexts (ir, hacer, tener), but in my opinion—as a fluent speaker of Spanish—the case was overstated.

Studies that compared English and Spanish speakers' performance in motion-event understanding, then, not surprisingly failed to show strong effects. Thus, Gennari and Sloman (2002) compared a group of English speakers to a group of Spanish speakers on how they described a series of simple movement episodes (in comparison to a condition in which no description was required), and then assessed their respective performance of both memory recognition and similarity judgment tasks. Their hypothesis was that Spanish speakers would pay less attention to the manner of the movements and would find motion events involving the same path more similar despite differences, even in nonverbal tasks, such as judging resemblance. Equally, they would confuse events that shared path but differed in manner in a recognition task. They failed to find an effect of language spoken in the recognition task, either in the linguistic description or in the nonlinguistic description conditions. They also failed to find an effect in the similarity judgment task in the nonlinguistic description condition; it was just when the events had to be linguistically coded that an effect was found in the similarity judgment task.

A different, more interesting tack taken on potential cognitive effects of crosslinguistic differences in verbs focused on inflectional morphology. In a series of studies, the influence of linguistic development on cognitive development was tested by Choi and Gopnik (Gopnik & Choi, 1990, 1995; Choi & Gopnik, 1995). They chose Korean as the contrasting language. While English is a barely inflectional language, Korean is a highly inflectional one. In addition, while in English the subject has to be explicit, in Korean it can be omitted, particularly in informal conversation in which the context makes common understanding possible. Given these linguistic differences, Choi and Gopnik hypothesized that Korean infants would be—in comparison with North Americans—advanced in action understanding (given their greater verbal sensitivity), but delayed in taxonomic categorization of objects (given their lack of practice with nouns). The results confirmed their reasoning, both with a longitudinal study and with a transversal study, using means-end and categorization tasks.

In general, this is an area of fruitful complementarity of different methodologies: linguistic anthropology and comparative linguistics provide interesting instances of structural differences among languages; cognitive anthropology relates those differences to cultural and environmental conditions; experimental psychology may show subtle differences in cognitive processing according to language spoken; a developmental perspective—both experimental and longitudinal—may reveal both the existence of universal preferential conceptualization schemes and/or the influence of linguistic development in configuring adult cognitive abilities. Even the contribution of comparative psychology may prove useful in finding out whether these universal preferential patterns are specifically human or they have older phylogenetic origins.

Taking advantage of this more mature approach, a recent trend has tried to investigate whether a schema for action events involving reciprocation can be established, parallel to the Talmy's schema for motion events (Dalrymple et al., 1994; Majid et al., 2011; Wierbicka, 2009). Again, the idea is to find out whether there are a set of cognitive dimensions involved in exchange events, but this time by asking which dimensions languages choose to code for in the first place. The goal is to find out whether a core universal concept of reciprocity is shared by all and to assess to what extent it is culturally and linguistically variable.

In English, for instance, reciprocal action requires some special grammatical constructions, such as the nominals "each other" and "one another," as in "give to each other" or "love one another." In Spanish, though, reciprocity is expressed by a reflexive particle "se," as in "darse" or "quererse" (which correspond to the previous English examples). While the English nominal "each other" can have an asymmetrical semantic meaning ("the man and the burglar chased each other") and can express a nonsimultaneous exchange ("they gave each other books"), the Spanish "se" verbal affix involves symmetry and simultaneity. But is there a common core of reciprocity that all languages share, despite differences in the grammatical way to express it?

The comparison of two unrelated languages, English and Chichewa (a Bantu language), concluded that their grammaticalized reciprocal constructions shared a core meaning (all subjects involved act on all others), which can be relaxed in some sentential contexts (Dalrymple et al., 1994). A study of English, Polish, Russian, and Japanese (Wierbicka, 2009), on the contrary, distinguished four distinct but related prototypes of reciprocity, in a continuum from reciprocity to mutuality to joint action and then to collective action. In general, the crosslinguistic comparison faces the methodological problem of making sure that the analysis does not privilege the semantic categories of one language over another. It was proposed, then, to apply in this domain the same method used for color terms: to design an extensional set of visual stimuli, and to ask participants of different languages to describe them verbally. The stimuli varied the relevant parameters to consider—from number of participants to symmetry, from simultaneity to configuration—in a systematic way (Majid et al., 2011). In this way, there is language-neutral ground for comparison.

Speakers of 20 languages participated in a study following this design (three speaker of each language as an average), sampling all language families. Through multivariate and cluster analyses, data were processed to find out whether there is a common pattern shared by all languages. Results show a considerable semantic overlap in categorizing reciprocal events. This commonality is modulated by considerable cross-cultural variation, however, specifically at setting the border of what counts as a reciprocal event. For some, a situation involving many people involved in partial exchange relations among them may not be described as reciprocal. Similar variations exist for other parameters, such as simultaneity and symmetry. On the other hand, languages differ in their grammatical encoding of reciprocity. One language, Kilivila, has no specific element in grammar for the encoding of reciprocity, just in its lexicon (despite the importance of exchange in their cultural practices). In the same vein, many more aspects of languages that are grammaticalized, such as modality, intersubjectivity, or person marking—and their different patterns of lexicalization—are amenable to these statistical methods that allow universal patterns in semantics to emerge, rather than the other way around. This is an area which is likely to attract more effort in the near future.

5.4 Gender Marking

A different area of study concerns the differences in gender marking and its cognitive consequences. Many languages indicate gender through morphology. In contrast to morphological number, though, gender is more convoluted. Even if number marking is complicated by the fact that the very divide between countable and mass nouns is language-relative, it always applies to countable nouns and it indicates the one versus more than one difference. Morphological gender, on the contrary, seems rather arbitrary, especially when applied to inanimate things. Examples abound, despite this not being the case in English. It is the case in Spanish, for instance. In Spanish all nouns are masculine or feminine (it is the feminine variant that is generally marked), even if the noun has a unique form. Thus, animate beings may have two forms, such as "león-leona" (lion), but inanimate objects are also gender-marked, though their gender does not change: "la puerta" (the door) or "el martillo" (the hammer). Gender agreement is a systemic requirement that applies to all nouns in Spanish. Another source of arbitrariness stems from choice of gender for inanimate objects: in German, "bridge" translates into “Brücke,” which is feminine; in Spanish, it translates into “puente,” which is masculine. “Butter” translated into French is “beurre,” which is feminine, and it translates into “burro” in Italian, which is masculine. To make things even more complicated, some languages distinguish more than two genders, for example, the neutral and the vegetative.

The effects of gender on language processing have been the focus of much attention. The most relevant result, though—in this context—is the finding that an interference in understanding is created when the grammatical gender does not coincide with the subject gender (Domínguez et al., 1999), especially when the conflict is created for anaphora resolution (Cacciari et al., 1997; Carreiras et al., 1996). Take, for example, the sentences: “Pedro fue atropellado. La víctima del accidente tuvo que ir al hospital.” (“Peter was hit. The accident victim had to go to the hospital.”). The name is masculine, but the subject is later referred to through a feminine word, so reaction times for understanding are longer. This strongly suggests that grammatical gender is processed at the semantic level, influencing how inanimate objects are conceived.

Previous research attempted to reveal this influence. Guiora et al. (1983) reasoned that children learning a gender-marking language would become aware of generic social differences faster than those learning a language that doesn’t make such a distinction. They got positive results. More recently, studies have examined this influence of grammatical gender on cognitive development on the assumption that grammatical gender would be associated with masculine and feminine prototypical properties, even for inanimate nouns. Thus, German and Spanish speakers were asked to rate a set of nouns on the dimension of potency (a masculine feature). Half of the nouns were grammatically masculine in German and feminine in Spanish, and half were the other way around (Konishi, 1993). Participants judged objects whose nouns in their native language were masculine to be more potent. Similarly, another study tested Spanish speakers on a picture rating task (Sera et al., 1994): participants were shown pictures of objects, and they were required to classify them as masculine and feminine. Again, they performed on the grounds of grammatical gender in Spanish. The effect was bigger if the pictures appeared labeled. They also found that 7-year-olds already performed according to grammatical gender when they were required to provide a voice for each picture: a masculine or a feminine voice was chosen according to grammatical gender.

In the same vein, Boroditsky, Schmidt, and Phillips (2003) compared a group of German speakers with a group of Spanish speakers, on a proper-names-learning task carried out in English. Proper names for 24 objects were introduced to participants (for example, calling an apple “Patrick”), and their memory of these object-name pairs was tested. Again, objects and names were chosen so that half had a masculine noun and half had a feminine noun in each language, and vice versa. The name to be learned was consistent with the grammatical gender of the noun half of the time, and it was inconsistent the other half. The prediction was that each group would better remember the consistent name–object pairs. An this is what was found: they showed opposite memory bias, in accordance with gender consistency. A control group of English speakers, though, did not show such a bias, proving that the performance by the Spanish and German speakers was affected by their native language experience.

To test whether grammatical gender might further influence cognitive understanding by focusing attention on masculine/feminine prototypical properties of objects, they also compared German and Spanish speakers on a task asking for the free recall of object properties. A list of 24 cross gender object nouns was selected, and participants were asked to write down the first three properties that came to mind for each object. Again, the study was conducted in English. The results also indicated an influence of grammatical gender on selection of properties: German speakers wrote masculine properties of an object when its noun in German is masculine, whereas Spanish speakers chose feminine properties of the same object because it has a feminine noun in their language. Thus, keys were attributed properties such as hard, heavy, jagged, metal, and useful, by the German speakers, while Spanish speakers' adjectives were golden, intricate, little, lovely, shiny, and tiny. Needless to say, the word for key is masculine in German and feminine in Spanish. The word for bridge, on the contrary, is feminine in German and masculine in Spanish. And this time, German speakers proposed properties as beautiful, elegant, fragile, peaceful, pretty, and slender, while Spanish speakers' terms were: big, dangerous, long, strong, sturdy, and towering.

Boroditsky et al. (2003) also improved on the picture rating task. They again compared Spanish and German language gender influence in a similarity judgment task, in which pairs of unlabeled pictures depicting objects and people were presented. Objects were again chosen on the grounds of a contrasting gender in both languages, but this time it was a nonverbal task. Both groups of participants rated an object more similar to a person when the gender of the object noun in their language and the biological gender of the person depicted was consistent, thus finding a converse pattern of similarity. Gender marking seems to play a role in cognition by inducing a cognitive categorization, which then gives rise to the well-known phenomenon of increased similarity between members of the same category. In addition, we seem to further this increased similarity by making the categories even more homogeneous: realizing that a group of objects goes together encourages looking for common properties that strengthen the perceived similarity among those objects.

Linguistic gender marking seems to have this increased categorical similarity effect, and it has also been proven to be relative to language semantics, rather than relative to a neutral conceptual level of representation, through a study comparing fluent English–Italian bilingual speakers (in which only the second language has gender marking), to English and Italian monolinguals (Kousta et al., 2008). In an error induction experiment, English monolinguals did not make semantic substitution errors due to gender, while Italians did. Bilinguals' behavior depended on the language in which the task was set, thus revealing appropriate representations for each language, rather than a nonlinguistic, conceptual effect. Bilinguals can shift between both semantic representations, as they shift from one linguistic code to the other.

5.5 Time

Time is an especially relevant linguistic arena for our purposes: it includes both lexical and morphosyntactic dimensions, that crisscross and co-determine each other in a complex way. As observed by Whorf, languages differ in terms of the time units they distinguish. As important as that is, languages also differ in the different aspects of time they require a speaker to morphologically mark (e.g., tense, aspect, and mode), and in terms of the means for temporal deixis they make available (e.g., now, tomorrow, and later). Moreover, most temporal concepts—just like abstract mathematical notions—are grounded in spatial metaphors (which entail different frames of reference; see Section 4.2), and languages also differ in which conceptual metaphors they use (Boroditsky, 2000; Casasanto & Boroditsky, 2008; Evans, 2004). As we will further see in Chapter 6, metaphorical grounding is a form of structural projection—of viewing the relations that structure an area of experience in terms of the relational structure that holds true in another area—and it is a distinctive feature of human cognition. Researchers have provided many examples of such metaphorical grounding of time on space: but there is no simple universal schema of this (Kranjec & Chatterjee, 2010; Matlock et al., 2005; Santiago et al., 2007; Torralbo et al., 2006). We have already considered the case of the Kuuk Thaayorre and their east-to-west understanding of time direction, which is related to their absolute frame of spatial reference (in Chapter 4). Reference to the influence of writing direction on time direction for English and Hebrew has already been made. But many other metaphors are used in different languages: speakers of English tend to use a horizontal spatial metaphor (past is behind, future is ahead), whereas speakers of Chinese use a vertical metaphor (future is down, past is up) (Boroditsky, 2001). The demonstration that this is not just a *façon a parler*, but that it reveals how events in time are conceived is found in the example that, given a spot in space directly in front of the subject to stand for today, when asked to place a spot for yesterday and tomorrow, English speakers use a horizontal axis, while Chinese speakers use a vertical one (Boroditsky, 2007). A similar metaphorical understanding could be argued for with regard to the Hopi: time as circular versus a linear conception of time. It is important to realize that this is an asymmetrical relation: time is projected onto space, but not the other way around.

Duration is also understood metaphorically, and different metaphors are also available. English speakers understand duration in terms of length (short and long events), while Spanish and Greek speakers conceive of time in terms of amount ("much" time). Research shows that speakers of different languages correspondingly differ in tasks—such as estimating duration—in ways related to the different metaphors of their languages. English speakers are more likely to believe that a line of greater length remained on the screen for a longer time, while Greek speakers are more likely to estimate that a fuller container was on the screen longer (Casasanto & Boroditsky, 2008). Finally, the work of Rafael Núñez on the Ayamaras' conceptual metaphors for time deserves mention (Núñez, 2008; Núñez & Sweetser, 2006). The Ayamara linguistic community is over two milion people; they live in the Andes highlands of Bolivia, Perú, and northern Chile. They reverse the central Western spatial metaphor time: instead of the projection "front of ego: future / back of ego: past," they use exactly the converse one. The basic word for front, "nayra," is also a basic expression meaning past, whereas "qhipa," which is the basic word for back, also means future. Thus, for example, "nayra mara," which translates literally as "front year" refers to the previous year.

Again, this is not a purely linguistic difference (a sort of frozen metaphor), but it affects how Aymaras understand temporal relations. In this case, Núñez found the evidence in the deictic gestures that accompany Aymaras talk of past and future: deictic temporal reference involved pointing to one's back to refer to future events and to one's front to refer to past ones, with distance from one's self-indicating temporal distance. Again, we find conceptual metaphors connected to flexible cognition and social scaffolding: abstract concepts are not hardwired in the brain, there are many ways to grasp them; each culture may succeed at this in a different way.

However, it is contentious whether all time concepts are similarly spatially grounded, at least if this is understood at the neural level (Gomila, 2008; Kranjec & Chatterjee, 2010). To begin with, it is possible to distinguish several possible conceptions of time: experiential, logical, and conventional (Friedman, 1982). Experiential time refers to subjective impressions of duration and time passing. Logical time corresponds to a theoretical, scientific understanding of time (which may involve some sort of scientific or technological system for absolute identification). Conventional time refers to the socially shared systems which organize temporal social phenomena (e.g., days, weeks, months, and year counting systems). In fact, logical time can be seen as a conventional social system with a privileged status. Conventional and logical conceptions of time clearly depend upon social practices and shared concepts in language, and they develop in late childhood, at an age of 9 years (Fraisse, 1982). Hence, it is reasonable to expect a spatial metaphorical understanding of these time frames.

The relevant question in this regard is whether linguistic coding of time—through spatial metaphors—also influences how time is experienced. Or, conversely, the question is whether experiential time is ontogenetically basic, and provides a universal starting point for grasping time, regardless of metaphors. So, the central question is whether experiential time is somehow language-dependent and metaphorically structured, because the conventional/logical systems clearly are cultural cognitive artifacts. But how could time be experienced, given that it cannot be directly perceived?

From a developmental point of view, linguistic acquisition of temporal terms begins much earlier than 9 years of age. If the unfolding of temporal understanding is revealed in verbal production, experiential understanding of time happens early in cognitive development. Thus, as children learn the terms and expressions of their linguistic communities, they have to make sense of the spatial metaphors they imply. The central evidence to consider is temporal deixis: the temporal relation between speech time and content/event time. This can be established either lexically (e.g., "yesterday," "now") or morphologically, through tense and aspectual morphology. The event may be past, present, or future in relation to speaking time and speaker; and it can be viewed as complete, as finished, or as ongoing and incomplete: the aspect is perspectival. It can also be seen as successive or previous to other events, and specified in terms of such relationships. So, the question turns out to be: how does experiential temporal understanding develop as revealed by the increasing complexity of temporal deixis in infant speech. Here again, a tripartite distinction of extrinsic, intrinsic, and egocentric frames of reference, corresponding to the three frames of spatial reference, suggests itself (Kranjec & McDonough, 2011).

As a matter of fact, lexical (and morphological) usage also presents a special ontogenetic pattern that reveals that type of cognitive development. According to Weist (1989), a developmental sequence of four temporal experiential systems can be distinguished, which follow a path from egocentric to intrinsic to extrinsic framework. These systems develop as children acquire language, starting at age 1;6, becoming able to understand and produce an increasingly complex network of temporal conceptions, up to the age of 4;6. Given that children experience grammatical language, the developmental sequence may reveal which temporal concepts are easier to grasp (for instance, because of a match between a prelinguistic concept and the linguistic one, or maybe because the linguistic item appears salient and robust). Weist's sequence of temporal systems is as follows: the speech time (ST) system, the event time (ET) system, the restricted reference time (RRT) system, and the free reference time (FRT) system.

The speech time system is a "here and now" communication system; speech time is the only functional concept, limited to the immediate perceptual environment. Children code events as if it occurred during the speech time interval; temporal reference is reduced to speaking time. The ET system appears with the first aspectual distinctions (perfect versus imperfect) by the end of the second year of life. It reveals taking a perspective of an event as completed or as continuing. It closely coincides with the past/nonpast contrast, which involves the distinction between event time and speech time. It is still not a temporal frame of reference in which events can be determinately located, however: events are just placed before or after speech time. During the period of 2;6 to 3;0, the RRT appears: a temporal context for an event is established, but just in relation to the speech time (that's why it is called "restricted"). Temporal adverbs and adverbial clauses, such as "yesterday" or "later," are used to temporally place the event in relation to the the moment of speaking. Finally, at 4;0 the free time system emerges, distinguishing speech time, reference time, and event time, and being able, by means of "before" and "after," to place past and future events in relation to each other according to a single ordering. Hence, while no temporal dimensions rely on spatial mappings, children do not have any other way to grasp temporal relations but linguistic resources.

It is important to realize that children lack any direct, perceptual experience of time. They experience motion and change, and even causality, but this just requires an implicit conception of time as succession and duration (which may also be language-sensitive, according to Mori, 1976). Hence, it is highly likely that time concepts develop out of linguistic prompting, in the effort to make sense of linguistic practice, but starting from some universally implicit understanding of successional and durational relations. The fact that some temporal terms rely on spatial relations, then, introduces a double level of the cognitive effects of language: languages select some such metaphorical projections onto space from those made available by spatial language itself. On the other hand, conceptual metaphor theory emphasis on schematic representation (Lakoff & Johnson, 1999) will require further discussion of this kind of representational vehicle in Chapter 8.

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6 Language as Tool Kit, 1: Representational Effects

In this chapter, I will review the studies that show the difference language makes to our minds. Many different ideas have been put forward in regard to this, including abstract thinking, propositional thinking, and controlled thinking; all have been viewed at some point as exclusive to verbal minds, brought about by language.

The traditional idea is that language is critical for abstract concepts (Gentner & Boroditsky, 1997). This is too simplistic, though, because any concept involves some degree of abstraction, of generalization, and of recognizing the commonalities behind diverse situations. A more acurate way to put it would be to say that language is critical for nonperceptive concepts, that is, concepts do not stem from sensorimotor contingencies or appearance features (such as form, size, or color).

Another direction would be to consider finer perceptive distinctions (Bedford, 1993), as in music or enology, in which the goal is to be able to recognize subtle differences within a kind of perceptual experience. In this case, it is phenomenal properties that are the target; the suggestion is that introducing a term may help one become able to distinguish Rioja from Cabernet. However, Bloom (1998) has argued that this role of language doesn't follow from a special representational power. What the label does is to mark the limit of the category, Bloom contends, something that could also be achieved with different sounds or lights associated with different sensory experiences. Hence, what is needed to prove the role of language in cognition is something stronger: evidence that the very categorical boundaries of our concepts are language-dependent.

This sort of evidence is also comparative, but a comparison of speakers of different languages, rather than a contrast of language versus nonlanguage conditions. If the conclusion of the previous chapter was that languages do not create cognition out of nothing—but that they bias or influence or restructure a basic, common conceptual capacity—the goal now is to show that nonverbal minds are strikingly different from verbal ones. The difference is not just a matter of a different pattern of generalization, but the very possibility that some capabilities derive from language. The "virtues" attributed to a verbal mind can be categorized as representational and as processual (even if both dimensions have to be taken together, as Anderson (1978) insisted). In this chapter, we will focus on representational effects; in the next chapter, on processual, or executive, effects.

Several strands of evidence may be relevant in this regard. On the one hand, we need to consider cases of language impairment, such as that in nonsigning deaf people, to analyze whether in such cases thought is also affected. On the other hand, we need to contrast cognition in linguistic versus nonlinguistic beings, such as apes. Finally, developmental evidence—regarding the influence of linguistic development on cognitive development—is also in order.

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6.1 Deafness

In this section, we will focus on congenital deafness. To begin with, it is an interesting exercise to compare the ways Pinker (1994) and Sacks (1989) tell the story of Ildefonso (Schaller, 1991), a nonsigning deaf person. While for Pinker this case amounts to a proof that language and thinking are independent, for Sacks it is a powerful demonstration of the critical role of language (needless to say, Sacks follows Schaller). Pinker underlines the fact that Ildefonso is capable of categorization, communication, and some elemental calculus, deprived of any symbolic means of communication (he does not pay similar attention to the difficulties Ildefonso has with concepts of time). For Sacks, it is just when Ildefonso grasps the symbolic nature of gestures that his thinking gets boosted (Schaller compares this first gesture understood—for cat—to Helen Keller's "water").

However, Ildefonso learned a sign language at 27 years of age, far later than the critical/sensitive period for language acquisition. It is possible that this case does not let us assess the full cognitive impact of language. Another widely discussed case is Theophilus d'Estrella, raised by William James (1893). Congenitally deaf, d'Estrella learned a sign language at 9 years of age. Later on, he published an autobiography telling of his initial experiences, which included elaborate views on religion and other abstract matters. Half-impressed, half-dubious, James remarked that if the account were reliable, it would cast doubt on the idea that abstract thinking depends upon words, and it would provide support for an image-based account of thought. While there is strong reason to doubt the possibility of propositional thinking in images, this story suggests that a visuospatial means of communication may go hand in hand with visuospatial cognitive capacity.

A precedent of such a result was already contributed by Bellugi et al. (1989). In a study comparing deaf sign language speakers to typically developing children, in a series of spatial tasks (e.g., spatial construction, spatial organization, facial recognition, and memory of graphical characters), they found that deaf children showed a superior performance. Bellugi attributed it to practice with their means of communication. In general, the iconic nature of sign languages may prompt their users to pay more attention to the visuomotor dimensions of experience (Pernis et al., 2010).

However, the right approach regarding this issue requires a systematic study of cognitive and communicative development in nonsigning deaf people, given the evidence that proves that sign languages are equivalent to verbal natural languages. Goldin-Meadow's (1999) work has focused exactly on that. She has observed deaf children of hearing parents, in oral study programs, which have the effect (already found in the de Villiers studies) of greatly delaying linguistic development. She's been particularly concerned with the gestural communication that spontaneously emerges among them, called "domestic signs," which are idiosyncratic and iconic or indexical, rather than symbolic (Goldin-Meadow & Mylander, 1984, 1990, 2000). Thus, their "lexicons" include pointing gestures and characterizing gestures (pantomimes). These signs are considered to be the expression of the concepts these infants already have available with which to face the language learning challenge. Remarkably, hearing children produce similar gestures (Acredolo & Goodwin, 1988), but deaf children's gestures constitute a structured system, which combines them into sentences (segmented by the motoric dynamics involved). She also observes that such gestural systems play a role not just in communicating with others, but also in communicating with oneself (Goldin-Meadow, 1998), as self-directed speech to support one's reasoning (*see* Chapter 7). Thus, she mentions as an example a case in which a child, faced with the task of copying the configuration of a set of blocks, does a gesture that refers to the next block, as an instance of planning. Again, this evidence is compatible with the general view that it is semiotic systems—not just the linguistic system *per se*—that play this cognitive-structuring role, while it should be kept in mind that language has some unique representational properties, such as referential displacement (Hockett, 1962).

For Goldin-Meadow (1998), this set of individual dependent gestures constitute a quasi-linguistic system, given that they are structured at different levels: orational, lexical, and morphological. Gestures can be combined and can be varied in their performance according to their communicative function (in a quasi-thematic role). This suggests a strong interactive link between communication and cognition, given that—as it is well known through historical records—deaf people prevented from communicative interaction became idiots (Sacks, 1989). At the same time, such spontaneous gestures express "biased" ways to categorize the experience (just as Imai and Gentner's work on the object/substance distinction suggests). It also paves the way for a similar role for symbolic communication (just as we saw with Steels' simulation) to stabilize and share concepts, as well as to grammaticalize as a compulsory way to pay attention to some dimensions of one's experience.

The most interesting result, though, concerns the claim Goldin-Meadow makes that this basic mode of communication is ergative. When it comes to expressing the actor/patient distinction, all languages distinguish actor from patient in transitive relations (like "Mary saw Peter"), but languages differ in how they treat the action in intransitive relations. Some languages can be accusative—those that treat intransitive actors as transitive ones—while ergative languages align intransitive actions with patients, rather than with transitive actors. If English were ergative, "Peter sings" would be expressed as "Sing Peter," or "Sing him." The ergative construction treats the intransitive actor as patient of the action, as affected by the singing, rather than as initiating the singing. It seems that spontaneous signing by deaf children (not exposed to a sign language) is also ergative.

For Goldin-Meadow (2003), this is an isomorphic case to the inanimate object one, in which an object can be treated both as object and as substance (Section 5.2), depending on the language one learns. However, the fact that spontaneously signing deaf children exhibit a bias for an ergative construction, introduces an asymmetry: it suggests a preferential bias for an ergative understanding. Thus, learning an ergative language should be easier than learning an accusative language for children, because it follows the prelinguistic predisposition to conceptualize such actions. This means that children learning English tend to produce words for intransitive actors and patients at the same rate, and both at a higher rate than for transitive actors (Goldin-Meadow & Mylander, 1984). As a matter of fact, such ergative construction of gesturing seems to be pervasive (DuBois, 1987). Goldin-Meadow also reports that English-speaking adults used an ergative structure identical to that of deaf children when asked to describe a series of action pictures using their hands.

Now, this raises two further questions: first, why are most natural languages accusative, rather than ergative? And second, do speakers of such accusative languages get used to an accusative understanding of events or do they keep the ergative one at the cognitive level? While Goldin-Meadow offers no answers, this line of questioning opens a challenging path of research. A possibility for exploration would be to consider whether the initial bias toward subject action provides an implicit understanding of the actor/patient roles, which facilitates language learning. Ergative construction in language, moreover, involves case marking beyond serial order, which still allows for some linguistically diverse ways to construe these relations in semantic space.

6.2 Nonhuman Primates

Another way to study the cognitive role of language is by comparing verbal minds with nonverbal minds, such as those of apes and nonhuman primates (Gómez, 2004). Since the cognitive capacities of nonverbal animals are clearly language-independent, it is useful to understand how cognition works in such species with respect to their abilities, their resources, their performance, and, therefore, what makes human cognition special (Penn et al., 2008). Thus, for instance, chimpanzees do not have voluntary control of vocalization, but they do have voluntary control of gesture.

However, it is particularly interesting to compare nonhuman primates in natural conditions to those that have been taught symbol systems. Such species do not naturally develop such communication systems, and it might be that the key to human cognition is related to whatever it is that makes us spontaneously create and learn such symbol systems. As long as learning such symbols increases the cognitive power of chimpanzees, it provides evidence that some cognitive abilities may be dependent upon language (or symbol use in general). This is true even if what chimpanzees learn is very far from a language: they develop small vocabularies with referential (rather than predicative) content, and they lack referential displacement and syntactic competence. Here we present evidence from three areas: relational matching, numerical competency, and spatial coding.

6.2.1 Relational Matching

According to Premack (1983), all mammals—plus some birds—are able to perform tasks of perceptual resemblance and spatial inference. However, analogical reasoning is much more selective ability: it is an uncommon ability. In his BBS paper, Premack says that chimpanzees might be able to solve such analogical tasks without symbolic support, but he demonstrates the facilitating effect of symbolic enrichment for "enculturated" chimpanzees: chimpanzees that have been trained to use symbols (Tomasello & Call, 1998).

Premack proceeded this way. In the first stage, Sarah (a chimpanzee) was trained to solve a perceptual resemblance task: given a sample object and two options—one identical to the sample, one different—Sarah was rewarded for choosing the same one.

Then, she had to solve simple relational tasks: shown a knife and two apples—one intact, one cut—she was rewarded for choosing the cut one. In the test phase, Sarah was shown a pair of objects and was asked to choose between two options which one was the "same" as or "different" from the sample. The critical aspect here was that Sarah understood the symbols for "same" and "different," and that the similarity to be judged was relational rather than perceptual. So, if the sample was "XX" and the options "XY" and "YY," and the question was "same," Sarah was able to choose "YY" (and the converse for the "different" question). In other words, by having explicitly grasped the "same/different" concepts "in the abstract," and by having learned to use the corresponding symbols, Sarah was able to grasp that the relation between "XX" and "YY" is the same, even if they look different.

As already mentioned, Premack does not say that it is by becoming competent at symbol use that Sarah achieves this capacity; he suggests that she might already be able to reason analogically without the symbols for "same" and "different." However, no evidence is available of such a capacity in nonenculturated chimpanzees, beyond a claim of implicit understanding of relational matching by infant chimpanzees: after handling a series of pairs of identical objects, they appear more interested in a nonidentical pair, and vice versa (Oden, Thompson & Premack, 2001). But this just shows that the chimpanzees notice the perceptual differences required to master the symbols for "same" and "different"—not that they code those differences as such—which is what is required for analogical reasoning. Conversely, symbol training is not sufficient per se, either, to yield analogical competence: macaque monkeys given the same symbolic training failed relational matching tasks (Washburn, Thompson & Oden, 1997). Premack proposes an interpretation in terms of two codes: an imaginal code closely tied to perceptual properties of objects and a propositional code learned with the symbolic system.

6.2.2 Numerical Competence

We have already mentioned (in Chapter 4) that prelinguistic children exhibit some basic forms of numerical competence before they learn the lexical system of numerals. Similar basic competence has been found in chimpanzees. Boysen has led a series of studies on quantity judgment among chimpanzees (Boysen & Berntson, 1995; Boysen et al., 1996). Participants are shown two arrays of candy differing in quantity (one versus three), and they receive the one they did not point to. In this way, it is possible to test whether the chimpanzees can distinguish the quantities and use that to act in a maximizing way (pointing to the smaller one to get the greater one). It turned out that the task was extremely difficult for the chimpanzees—in spite of the fact that the participants had been trained in number symbols, just as Matsuzawa (1991) had managed to teach Ai to count up to six with number terms. However, when the same task was carried out using numerical symbols, the chimpanzees readily selected the smaller numeral, thus getting the bigger reward. It seems as if the symbols lack the sensory power of attracting a preponderant response to the reward itself. Symbolic stand-ins facilitate executive control because their abstract content just involves magnitude.

6.2.3 Spatial Coding

We have already discussed crosslinguistic studies of spatial language. In this section, we will present some experiments suggested by the realization that some languages preferentially use absolute frameworks to code for spatial directions (like the cardinal points), while others use intrinsic and/or egocentric frameworks. Thus, the question raised here is: which spatial framework do nonhuman primates use?

In the first study (Haun, Call, Janzen & Levinson, 2006), the question of location identification was first raised for all members of the *Hominidae* family: gorillas, orangutans, chimpanzees, and bonobos, in comparison with 1-year-old human (prelinguistic) babies and with 3-year-old, already verbal, infants. A "hide and search" task was set, in which the participants saw an experimenter hide a reward under one of three visually different containers. While a black screen (or a curtain) prevented vision of the setting, the containers shifted their positions. Then, the participant could again see the setting and could point to one of the three containers to get the reward, if right. While prelinguistic babies did as all of the great apes did—in pointing to the place where the reward disappeared, rather than to the container under which it disappeared—3-year-olds' patterns were the reverse. This is a short-term spatial memory task, but it clearly suggests an evolutionary transition associated with language mastering. Nonlinguistic subjects paid attention to places in space—rather than to landmarks such as the containers—which indicates a coordinate system: a sort of cognitive map. As a consequence, they were successful in those trials in which the containers changed position, but the reward remained in the same place. Notice that in this case, all of the containers were of the same shape (that of a half sphere), but differed in appearance (half coconut, wood, and ceramics). It might be that a different choice of containers could have made them more salient. Even so, the same containers were used for the 3-year-olds.

Given the result indicating that all hominids are biased toward a coordinate system of spatial orientation that involves geometrical relations (*see* Section 6.3.3), the question to ask is which type of coordinate system it is: whether it is a relative or an absolute one. Three types of systems have been distinguished (Section 4.2): intrinsic, egocentric, and allocentric - absolute, but the first two are both relative the egocentric being like the intrinsic, but for using the ego as landmark. To answer this question, then, a second study was carried out by these researchers (Haun, Rapold, Call, Janzen & Levinson, 2006), again across the whole *Hominidae* family. In this test, again the participants saw bait being hidden under one of three containers. Now the subject was rotated, however, and then had to choose between another set of three containers to find the object (a cross-mapping search task, similar to another will discuss in the next section). After the turn, two different mappings were possible. If participants represented spatial directions in a relative framework, they would point to the same relative position ("the one to the left"), while if they represented them in an absolute framework, they would point to the one standing in the same "absolute" position ("the one to the north"). This time, all participants—the 4-year-old German speaking infants included—preferred the allocentric coding of space.

This suggests that absolute linguistic coding—despite its greater complexity and abstraction—better matches the initial spatial preference in babies, along with that of the rest of the *Hominidae* family. Using a modified version of the task (with five cups) to make it slightly more difficult, adults and children of around 8 years of age from two cultures were compared. One group had an absolute reference language (Akhoe Hai, from Namibia), and the other had a relative one (Dutch). The results indicate that by 8 years of age, Dutch speakers already prefer a relativistic coding, changing the preference in this type of nonverbal task according to language preference. However, it is dubious that the understanding of space—after a symbolic code of directions and positions is learned—remains the same, as implied: even if it makes sense to claim that all hominid cognitive maps are allocentric, acquiring the semantics of absolute terms of spatial reference seems to imply a different understanding of space itself. For one thing, there are no abstract cardinal points or fixed absolute reference points in animal cognitive maps.

6.3 From Nonverbal to Verbal Minds

We have already advanced—at several points—another approach to assessing the cognitive difference that language may make, by considering nonverbal cognitive competence in infants. The goal is to ascertain the cognitive transformation prompted by linguistic acquisition, especially for certain aspects of early linguistic learning. The background assumption is that initial nonverbal cognitive preferences may explain why some linguistic forms are learned first, while late cognitive achievements may be associated with greater linguistic and cultural influences. However, a prudent strategy should not assume a single model in this regard, as we have already criticized in modularistic architectures. For some domains, a greater phylogenetic drive is expected (just as it seems to be the case with space, as the last studies reviewed suggest). Other cognitive areas may turn out to be language-relative (like gender marking or the coding of manner and path in verbs of movement)—hence, no initial bias may exist. The emphasis, at any rate, is on the qualitative changes induced by language: the crucial difference lying in having a language versus not having one.

6.3.1 Relational Terms for Analogical Reasoning

Gentner (2003) has argued that the development of relational language—more precisely, the acquisition of relational concepts through language acquisition—facilitates the development of analogical reasoning, which is one of the differential features of our cognitive capabilities. For Gentner, all languages include relational terms, so it is not a matter of comparing one language to another to assess differential cognitive effects. Moreover, relational concepts are difficult, because they are more “abstract”: they are not grounded in superficial, perceptual properties. Hence, they are learned later than concepts of individuals or substances, which can have such grounding. Her point is that relational thinking—as analogical reasoning—is facilitated by (not made possible by) the linguistic acquisition of relational concepts (which might also be acquired some other way). As a matter of fact, relational thinking appears gradually between 2 and 5 years of age, according to domain and task difficulty (Goswami, 2001; Namy & Gentner, 2002; Richland et al., 2006).

Given the centrality of relational thinking in Gentner's account of human cognition, as the source of modeling, abstraction, and flexibility, such a facilitating role is of great importance in development. For 4-year-olds, relational categorization is still a difficult achievement, because it requires them to overcome stronger first-order perceptual resemblances—which make nouns for classes of objects easier to learn. As a matter of fact, from a relational point of view, two perceptually identical objects may not go together—one may be "on" and the other "under." Relations may be spatial, temporal, or functional; may be context-dependent or goal relative; and open-ended: there is no limit to the number of potentially relevant relations. Therefore, linguistic practice offers children a guiding role as to what relations are relevant. It points out which relations should be paid attention to, in a sort of bootstrapping process, in which the child has to make sense of the term to project its meaning in novel situations (meaning projection of new words is studied in the lab by means of pseudo words). This also makes the relevant relations cognitively prominent, favors their memory, and aids their recovery in new situations.

As evidence, Gentner carried out several studies to test such an approach. In Ratterman and Gentner's study (1998), the facilitating effect of relational language is illustrated with a cross-mapping search task, in order to create a conflict between a mapping based on perceptive resemblance and a relational one (in this case, spatial). There are two sets of three containers of different sizes. One set is placed, in size order, in front of the experimenter, and the other set is placed in front of the participant. In this way, the largest container in one set is the same size as the middle container in the other set, and so on. The participant sees the experimenter hide a reward under one of the containers of her set, and the task consists in finding a similar reward under the corresponding container of the participant. A nonrelational response would mean that the participant goes for the container of identical size; a relational response means the participant goes for the container of corresponding relative size. Participants are always shown the correct response after they choose.

Three groups of participants were included: aged 3, 4, and 5 years old. In the first study—designed as a baseline—no linguistic labels were used and performance was barely over chance for 3-year-olds, while 5-year-olds' performances were almost perfect when simple containers were used (same shape, different sizes). On the other hand, even 4-year-olds dropped to chance level when complex containers were used (differing both in size and shape). In the second study, the experimenters introduced the lexical labels "father/mother/baby," or "big, little, tiny," applied to the containers according to their relative sizes. The 3-year-olds, in this condition, reached the same performance as 5-year-olds in the baseline condition, both for simple and for complex containers. In a further experiment, transference of relational mapping to new triads was established without further use of relational labels, and it was shown that the effect was due to such labels, given that if another series of terms was used, no such effect followed. These effects were still present 4−6 weeks later. The conclusion is that use of relational labels facilitated children's efforts at noticing and representing relative versus identical size as the key to solving the cross-mapping search task.

To investigate the specific influence of spatial language on spatial reasoning, Loewenstein and Gentner (1998, 2002) chose the spatial prepositions "on, in, and under," which are terms that appear early in lexical development (Bowerman, 1989), but which express spatial relations for which not all languages code (*see* Chapter 4). Again, the cross-mapping search task was set to establish a baseline to assess whether using these relational labels would improve performance. In this case, the child was shown two identical sets of shelves, with a three possible locations: one on top, one in the middle, and one at bottom. These shelves were called, the hiding box, and the finding box. In each of the three locations, a card was placed. One card in each set, with a star on its back, was the winner. Participants were shown the location of the winner at the hiding box and had to find the winner in the corresponding location at the finding box. Given that all cards looked alike, the only way to solve the task was by taking into account the spatial relations between both shelves.

In the control condition, the statement "I'm putting the winner here" was said to participants while placing the target card. In the experimental condition, the statement "I'm putting the winner on/in/under the box" was said to participants. Again, use of linguistic labels greatly improved performance: at age 3;6, children in the experimental group outperformed children in the control group, who were barely above chance. At age 4;0, this beneficial effect disappeared, indicating that all children had already internalized the relational system. However, if the task was made more difficult, by changing identical cards for different objects differently placed—thus creating a response conflict with the option to choose based on object similarity, rather than same relative location—4-year-olds performed at chance in both conditions. Up to age 5;2, beneficial effects of relational language were found.

To make sure that the effect was due to semantic content, rather than to a general attentional effect, the locative terms "top, middle, and bottom" were used. These terms form a system of relative positions, while each preposition expresses a separate relation between a figure and a back ground. When these terms were used, even 3-year-olds were able to encode and map spatial relations and, thus, solve the task. These benefits were still present a few days later, when participants were brought back to the lab to "play the game again," this time with no mention of spatial terms. Again, the results suggest the conclusion that overt use of relational language invites children to use relational concepts: those provided by the language they are learning.

6.3.2 Object-Centered Terms and Flexibility in Spatial Cognition

Now I'm going to focus on another particular class of relational terms: object-centered spatial descriptions, like "behind the tree" or "to the left of the wall." It has been claimed that object-centered spatial terms to improve flexibility in spatial cognition, during early development. I have already discussed work on lexical differences in spatial and geometrical vocabularies, in order to consider their purported differential cognitive effects (in Chapter 4). I have also just reviewed differences among nonhuman primates, nonverbal infants, and verbal humans in how the code for objects in space differently (Section 6.3.3). Now it is time to go beyond geometry, to consider the integrative dimension of spatial language and its processual effects. This time, though, such processual effects—of increased flexibility—are thought to be due to representational format, rather than executive function improvement. That's why we include them in this chapter, even though they could also be considered in the next, as flexibility effects. It will turn out to be clear in the next chapter that such processual effects depend upon integrative representational formats that allow for greater cognitive control.

In a pathbreaking study to assess the role of language in spatial cognition—using an interference dual task paradigm to block the cognitive effects of language—Hermer-Vázquez, Spelke, and Katnelson (1999) compared prelinguistic children, human adults, and rats, on a reorientation task. The research took as a starting point the previous findings that children and rats use only information about the shape of the environment to reorient themselves (Hermer & Spelke, 1996), while human adults reorient themselves in a more flexible manner, by conjoining geometric and nongeometric information to specify their position in space (Hermer & Spelke, 1994). The hypothesis that such a difference in cognitive flexibility is related to language is examined in the paper we are reviewing through a series of studies. While the research was inspired by the "language as modular interface" theoretical position—according to which flexible cognition is related to integration of several sources of information made possible by natural language—the studies and their results are interesting themselves. In Chapter 8, we will discuss which theoretical position best fits the available evidence.

Spatial cognition—including navigation, orientation, and spatial memory—is a central capacity of mammals, which exhibits great continuity along the phylogenetic tree. Hermer-Vázquez et al. (1999) review the evidence showing that all mammals—including humans—construe and update allocentric maps: an ability that makes novel trajectories possible. The evidence of phylogenetic continuity with respect to this attribute includes the brain structures involved—like the hippocampus and parietal cortex—which are the same within the family, and even sexual dimorphisms and seasonal changes in their working are shared by these different species. However, human spatial cognition presents two innovations: it is highly variable across circumstances, individuals, and cultures (Levinson, 2003) and people navigate with great flexibility, using all kinds of symbolic devices (e.g., verbal directions, maps, and compasses) and sources of information (e.g., position of stars in heaven, milestones, landmarks, and indications) (Hutchins, 2005). Both aspects can be viewed as related: it is because it is flexible that it can vary from case to case. Conversely, nonhuman mammals behave very consistently; hence, it is hard for them to learn new tasks, which humans quickly master.

One of these tasks, first used experimentally with rats (Cheng, 1986), is the "disorientation and reorientation task." After the rats familiarized themselves with a closed rectangular chamber and were able to identify the location of a single food source at one corner, they were removed and disoriented. Later, they were returned to the chamber and allowed to search for the now hidden food location. The location where the rats first search for food indicates the memory information they use to reorient themselves. The shape of the chamber is an ambiguous cue, because the corners are diagonally identical; if rats use that cue, about 50% of the time they will end up in the opposite corner. Food source is completely specified by variable wall brightness and odor. If rats reliably find the food source, it is because they are using these cues. Notice that it is reorientation that's at issue here, not how rats spatially represent the target corner in the first place (even if it is assumed that it is an absolute frame of spatial reference, something like "north corner," rather than an egocentric framework, as already discussed in Chapter 4). Where did the rats search? Rats looked equal amounts of time at the correct corner and at the diagonally opposite corner, despite the rich information cues that could be used to resolve the ambiguity of a memory based on geometry only. This suggests that the latter was the information their memories of the chamber included. However, rats are able to use the other sources of information—like odors and brightness differences—in solving other tasks.

Cheng (1986) thus concluded that spatial reorientation in rats depended on a module of geometrical knowledge. While it is debatable whether there exists a specific module for reorientation, the relevance of geometrical cues for reorientation is indisputable. The environmental setup is enduring and rarely involves deceptive symmetries. Most other cues—plants, odors, colors, object configurations—can be transient, hence, less reliable. Not surprisingly, rats are not alone in focusing on geometry for reorientation: many other species do the same (O'Keefe & Burgess, 1996). Among the latter are human children: previous research by the Spelke group modified the reorientation task to be set to 18- to 24-month-olds (Hermer & Spelke, 1994, 1996). Instead of a food source, the target in the corner was a hidden toy: children witnessed how it was hidden, and after becoming disoriented by being lifted and turned, they had to search for it. During one round of the test, no distinctive landmark was added to a completely white chamber, so that only ambiguous geometrical information was available for the infant. During a second round, a blue wall was added to break the chamber symmetry. Just as the rats did, infants looked equally at the two geometrically identical corners—even during the second round—when a disambiguating cue (the blue wall) was available. Other disambiguating cues were used (e.g., a texture or a pattern on the wall's surface) to no avail, despite the fact that all of these other sources of information are used by infants for other tasks. On the contrary, human adults do use such disambiguating cues in the reorientation tasks, if available (Hermer & Spelke, 1994). In conclusion, it seems that infants rely for reorientation on a robust—but geometrically specific—system, while human adults can reorient in a more flexible manner, using all kinds of disambiguating sources.

The source of this flexibility—understood here as the possibility of choosing which information is to guide action—it is argued, has to do with the development of spatial language. At about 4 years of age, object-centered spatial expressions such as "at the blue side" and "behind the wall" appear, while "left" and "right" first occur around 6 years of age. Correspondingly, success at the reorientation task when the toy is hidden to the left or the right of the wall, does not occur until age 6. To find out whether the causal connection that sustains this correlation is due to the fact that natural language provides a medium of representation in which multiple cues can be flexibly integrated (as proposed by the "language as modular interface" theory), the studies reported in Hermer-Vázquez and Spelke (1999) were carried out. This time, a dual task method was used with adult participants, on the grounds that language processing cannot be split between two processes at once (Broadbent, 1971). Thus, it was hypothesized that if linguistic processing was prevented from becoming involved in the reorientation task by being assigned a different, concurrent task, adult performance would rely solely on geometrical information, just like prelinguistic infants.

This second task was a verbal shadowing one, during which participants had to repeat aloud what they heard through earphones. Under this condition, participants searched equally at both geometrically identical opposite corners, even if the color landmark was available. Thus, verbal shadowing impaired adult's ability to combine the color of the wall with the geometrical configuration, but it did not impair the latter, suggesting it is an automatic and phylogenetically robust trait. Use of color and other landmarks, on the contrary, seems to rely on language, given its sensitivity to verbal interference. To make sure that this effect was due to verbal interference, a different interference task of similar difficulty was used: a nonverbal rhythmic tapping. Under this condition, the second task did not create an interference, and subjects were able to find the hidden object in the right place.

However, it is not clear how verbal shadowing interferes with the reorientation task. Hermer-Vazquez and Spelke (1999) suggest—in keeping with the "language as modular interface" theory—that it may have this effect by preventing the subject from using those more elaborate spatial expressions. Those expressions, such as "left" and "right," would be required for unambiguously coding the hidden object in relation to the landmark ("left corner of the blue wall"), given that both egocentric and absolute coding frameworks are affected by the disorientation. (It would be interesting to find out how the "absolute coders of space" studied by Levinson would deal with such a task.) Thus, in order to better understand the effects of verbal interference on spatial orientation, further studies were carried out to assess whether—despite their inability to conjoin geometric information with the nongeometric disambiguating cues—participants detected and remembered the latter, suggesting that verbal shadowing specifically affects the integration of geometric and nongeometric information in memory. In the same vein, it was shown that such effects of language are not circumscribed to reorientation tasks, but are present in other spatial tasks as well, such as in locating a moving object.

The interference effects of verbal shadowing have been interpreted as evidence that in the nondual setting, spatial reorientation is flexible because it takes advantage of a linguistic representational vehicle. However, dual task conditions clearly increase processing demands, at least with regards to the monitoring and updating of working memory (Baddeley, 1990). In other words, Hermer-Vázquez and Spelke (1999) do not rule out an explanation of these cognitive effects of language on spatial representation in terms of executive functions. On the one hand, verbal shadowing could have made it more difficult to pay attention to the right combination of perceptual cues, as well as making it more difficult to label them in an object-centered unambiguous manner; the effects could also be due to the impossibility of keeping such a description updated in working memory—if it were produced at all—to be properly reminded of later. Finally, verbal shadowing is a very demanding task that needs a fair amount of training; in fact, it can be considered a dual task in itself, in that it requires one to keep selective attention focused on the right perceptual source plus it requires the appropriate linguistic production (which is not purely phonetic, but involves at least lexical access). In summary, while the author's account of the effect is in representational terms, the effect—in itself—is processual. That's why it has been included in this chapter, rather than in the previous one.

In general, though it is clear that there has to be a connection between the representational and the processual effects of language, as there is a general connection between representational format and kind of process for that type of representation. Call it metarepresentation, relational properties, inner speech, or cognitive complexity—which we will discuss in the next chapter— that is made available by language acquisition, cognitive effects also have a processual dimension, related to increased cognitive control. It is not easy, though, to disentangle the order of causality, maybe because the right way to think of verbal minds is not as a single factor causing some effect, but rather in terms of complex relationships and interactions along a developmental path. Perhaps this gives verbal minds their distinctive cognitive powers, which make possible the set of activities that characterize humanity.

6.3.3 Sentential Complements and False-Belief Attribution

There is a growing body of evidence that points out clearly that the socio-cognitive capacity called "theory of mind"—the ability to attribute propositional attitudes to others to make sense of their behavior, and specifically the critical milestone of false-belief attribution, which typically occurs at 4 years of age—is grounded in socioperceptive capacities. Such socioperceptive abilities such as facial imitation (Meltzoff & Moore, 1989), primary and secondary subjectivity (Trevarthen, 1979), and joint visual attention (Baron-Cohen, 1991; Gómez, 1991; Leslie, 1994; Eileen et al., 2005) may provide an implicit understanding of epistemic relations (Dienes & Perner, 1999). This would manifest in eye gaze or attention, but without allowing for explicit reasoning and belief attribution. These more basic, interactive abilities have been called "second personal" (Gomila, 2001; Reddy, 2009), and their role in language learning is well established (Baldwin, 1993; Bloom, 2000; Tomasello & Kruger, 1992) as a cueing of symbolic meaning by the intention with which it is used. Recent research has shown that such implicit understanding can be found much earlier than previously thought (Clements & Perner, 1994, reported that infants of 2 years and 11 months already show sensitivity to error through their looks). Thus, Onishi and Baillargeon (2005) found that even 17-month-olds' looking times—in a habituation-dishabituation paradigm—dishabituate to situations where agents seem not to behave according to their knowledge. Southgate, Senju, and Csibra (2007) replicated the Clements and Perner paradigm in a nonverbal way, and found that 2-year-olds' eye gaze reveals the expectation that a person will look for an object where she last saw it. Even more recently, Kovács et al. (2010) revealed implicit sensitivity to others' beliefs even at 7 months of age.

However, socioperceptive understanding doesn't require attribution of mental states as internal states of the subject with propositional content. It rather relies on interactive generalizations like "people seek an object where it is, or where they last put it" (Povinelli & Vonk, 2003): what could be called a "see-know" principle. This principle requires simplified tasks, during which the participant is not required to do anything or to answer any question, but just to look. In fact, in the Southgate et al. design, in the situation in which the object displacement was not seen by the protagonist, the object is taken out of sight—rather than hidden in the other container—as a way to make it processually simpler. This eliminates the preponderant response that a misleading perceptual stimulus may ellicit. It is in this context, it has been argued by the de Villiers in a series of papers, that the development of false-belief, explicit attribution is conditional upon (or in a weaker version, is facilitated by) syntactic development: false-belief attributions involve tensed sentential complements. In other words, the ability to attribute the false belief "John thinks that London is the capital of France", is dependent upon mastering the "X believes that S" syntactic structure.

Notice that it is a specific theory that goes beyond the well-known fact—attested to by longitudinal studies—that success in false-belief tasks correlates with linguistic development (Astington & Jenkins, 1999). It focuses on the development of a specific syntactic structure as the key to success in false-belief tasks. Let's see the support of this proposal. In a longitudinal study, Bartsch and Wellman (1995) realized that the appearance of psychological verbs (e.g., "want," "like," and "wish") in infants' vocabulary happens at year three. It is important to notice that when psychological verbs appear, the thematic structure of these verbs is dyadic ("X wants Y" rather than "X wants that S"), but does not require a tensed sentential complement. Instead, the structure requires only a nominal or infinitive complement. Infants may say, "I want an apple," or "I like to sing," rather than "I wish you were here" or "I'm happy that John is not here." Shortly afterward, epistemic verbs (e.g., "believe," "think," "forget," and "know") appear. These verbs do require a tensed sentential complement ("I believe John has come"), which can be true or false quite independently of the truth of the whole sentence.

According to Bartsch and Wellman, these words are initially produced by children without a complete understanding of their meaning, in stereotypical verbal routines, such as "I don't know". However, at the end of the third year of life, these verbs appear already in a propositional attitude context, as self-attributions of true beliefs. It takes another month for the false-belief attribution to others to appear, and several months before false-belief tasks are passed (*see* Perner, 1991).

For Wellman, this developmental pattern is interpreted as a change in the ability to use such representations in the context of action explanation, rather than a change in the very capacity to represent false-belief contents. According to this view, what we find in language use is the expression of an independent cognitive process. However, there is also a different way to interpret this developmental pattern, which provides a critical role to the achievement of the complementizer syntactic structure as a footbridge for the mastering of false-belief attributions (J. de Villiers, 1995, 2005; de Villiers & de Villiers, 2000, 2009). According to this view, reasoning about propositional attitudes is contingent upon the mastering of the required representational format, one that allows for the truth of the attributed mental state, without commitment to the truth of the content of that state. For the de Villiers, children get this type of representational structure available for "theory of mind" false-belief tasks once they master the corresponding syntactic structure: the kind of embedded propositional structure of complement clauses (a typical example, by the way, of the general property of linguistic recursivity). The explicit understanding of false-belief attributions, then, would depend on the mastery of complement clauses. In general, this linguistic mechanism is thought to be crucial in making possible a metarepresentational space: of representing representations (rather than objects, states, or processes), but the de Villiers propose a much more precise hypothesis.

In order to provide evidence for their proposal, they operationalized complement understanding through indirect speech ("John said yesterday that Mary speaks German"), which is structurally equivalent to propositional attitudes (the report may be true while the reported fact may be false). It also may take similar complements as psychological verbs. Indirect speech also appears before propositional attitudes in the speech of children (Bartsch & Wellman, 1995). They realized that 3-year-olds fail questions such as "When did John say that what Mary speaks?" by answering "German," instead of "yesterday." This reveals that their syntactic development has not yet reached such a subordinated structure. These sort of questions they call a "memory for complements test," and they don't require the child to infer a mental state, the questions just involve language understanding. It is only once children master such a structure that they become able to pass false-belief tasks—a correlation that suggests a causal connection.

Support for this causal connection comes from two kinds of studies: those of typically developing children and those of (developmentally delayed) deaf children learning the oral language of their communities. They have done both: on typical (de Villiers & Pyers, 1997, 2002), and deaf infants (Gale, de Villiers, de Villiers & Pyers, 1996), and both provided positive evidence that syntactic acquisition of complement clauses predicts passing false-belief task tests. These studies have been amplified lately in a large study with 180 oral and signing deaf children (P. de Villiers, 2005; Schick, de Villiers, de Villiers, & Hoffmeister, 2007). In this large study, they included oral deaf children with language delays; signing deaf children of hearing parents, who are acquiring American Sign Language (ASL), but with some delay; and signing deaf children with deaf parents who were exposed to ASL at birth and so acquired language without delay. Several measures of false-belief attribution were included—both verbal and nonverbal—plus the "memory for complements" test, plus other control measures of syntactic productivity. Again, the results showed the same predictive relationship between complement comprehension and false-belief reasoning, for both groups of deaf children. In the case of children with the delayed development of language, the results are clearer, because the time course is longer and the variability greater. Whether the delay is due to a delayed learning of ASL or oral English, the understanding of complements was the highest predictor of false-belief understanding, even in nonverbal false-belief tasks.

Their evidence has been replicated in other languages, such as in German (Perner et al., 2003), ASL (Schick et al., 2007), Bulgarian (Kyuchukov, 2006), and Tibetan (de Villiers, Speas, Garfield, and Roeper, 2007). Similar results were obtained with deaf signers of Nicaraguan Sign Language (Pyers, 2004). Older signers in the group with an incomplete knowledge of sign language—including a lack of mental verbs with complement clauses—failed false-belief tests. Younger members of this linguistic community—with a more complete knowledge of complement clauses—passed the tests.

Recently, the de Villiers have used the "linguistic interference" paradigm we saw in section 6.3.2 on spatial representation (Newton & de Villiers, 2007). While participants solved a nonverbal false-belief task, they had to be either tapping a rhythm or shadowing a voice (to make sure the interference was due to the activation of the linguistic system in the shadowing task, rather than due to a dual task in general). Remarkably, in the shadowing condition adult participants performed like 3-year-olds, thus failing the false-belief task, thus demonstrating the engagement of language with explicit false-belief attribution.

These results are also convergent with research on autistic individuals (Astington & Jenkins, 1999; Happé, 1995; Tager-Flusberg & Sullivan, 1994), in which correlations between linguistic ability and passing false-belief tasks have also been found. A more recent study with autistic children also found that mastery of sentential complements with verbs of communication predicts improvements in false-belief understanding (Tager-Flusberg & Joseph, 2005), just as it did with typically developing children (Hale & Tager-Flusberg, 2003).

However, their theory of sentential complements as the key to false-belief attribution, has not gone unchallenged. One question raised relates to whether complements are universal. If they are not, speakers of languages lacking them should not exhibit false-belief attribution either, unless there are other possible linguistic mechanisms to represent content embedded into other content (Joshi, 2007; Hollebranse & Roeper, 2007; Roeper, 2007). This question is of special interest concerning languages such as Chinese, as we already saw with respect to counterfactuals (*see* section 5.1). In Chinese, the lack of surface markers of complementation makes the "memory for complements" task very difficult for children, a fact that could be compensated for in this case by the existence of a verb which means "to think falsely" (Tardiff et al., 2007). On the other hand, it should be kept in mind that it is assumed that everybody starts with an implicit understanding of theory of mind, so that complements are a way to make explicit what is already implicitly grasped.

A more interesting challenge to this proposal, though, stems from the Perner study with German (Perner et al., 2003). In German, desire attribution requires tensed sentential complements when the subject of the main sentence is different from the subject of the sentential clause; in other words, when somebody wants somebody else to do something. But, as with speakers of English, the developmental patterns of propositional attitude attributions are the same: desire attributions come before belief attributions (by 1 year). So, even if mastering sentential complements may be necessary for propositional attitude attribution, it cannot be the whole story—otherwise, Germans should exhibit false-belief attribution when they master sentential complementation for desire attribution.

The de Villiers have tried to respond to this challenge by looking for a syntactic feature that may differ in verbs of desire *vis-à-vis* verbs of belief (de Villiers, 2005; de Villier & de Villier, 2009). It is suggested that beliefs take "realis" complements, while desires take "irrealis" complements. This is an unclear way of capturing the old notion of "direction of fit" (Searle, 1969): beliefs have a "mind-to-world" direction of fit while desires have a "world-to-mind" direction of fit. While put this way the distinction may make sense, (a) it is a semantic distinction, not a syntactical one and (b) it concerns the mental verbs themselves, rather than the sentential complements they take. However, it suggests a way to complement the de Villiers proposal, by explaining why belief attribution comes later than desire attribution, even for speakers of languages that are able to master the tensed sentential complement syntactic structure early on.

As observed by the longitudinal study of Bartsch and Wellman (1995), belief attribution appears after indirect speech report. The studies of Hale and Tager-Flusberg (2003) and Lohman and Tomasello (2003) show that training in communication verbs—which is the linguistic context in which English-speaking children encounter tensed sentential complements in the first place - accelerates the appearance of belief attribution. This suggests that belief attribution is not only connected to indirect speech report—not just by this syntactic link—but also semantically/epistemically (Van Cleave & Gauker, 2010). It is in this speech report context that the child finds the possible divergence between fact and subjective perspective in the first place. "Belief," then, appears in development as a way to report on other's assertions and might later on adopt an explanatory-predictive role. Tensed sentential complements are the vehicle for the representation of nonfactuality, but for belief attribution the appropriate discursive context of use is required. Another way to put the point is to say that syntactic acquisition cannot be divorced from its functional context: of meaningful encounters with those structures (Tomasello, 1998). Again, the point is not that "theory of mind" appears "out of the blue" as a side effect of the acquisition of a new syntactic structure; it rather suggests how linguistic development transforms a previously independent capacity, giving rise to a new level of cognitive competence.

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7 Language as Tool Kit, 2: Executive Effects

In this chapter, further evidence of the processual effects of language will be analyzed. In a way, the representational effects of the previous chapter entail some corresponding processual effects, given the close connection between representations and their related mental operations. Sometimes this is just taken for granted (Penn et al., 2007) or connected with the general distinction between "automatic" and "controlled" processes (Carruthers, 2006; Spelke, 2003). This is a most unfortunate choice of words given that—according to control theory—automatization is the way to control a process. The intuition is that—by developing new, linguistically sensitive ways to conceptualize one's experience—a subject faces potential conflicts between rival ways of making sense of a situation (just as Gentner pointed out regarding relational language). Being able to use these new processes of conceptualization, then, is not just a matter of "turning on" the right concept, but rather of choosing which one—of the multiple concepts available—is to be activated. Such an ability implies an executive dimension, which may involve both selective attention to some feature of interest and inhibition of the prepotent response (be it cognitive or motor, more on this distinction later). Thus, getting new representational possibilities is not just a matter of acquiring a more fine-grained representational system, but also a matter of becoming more flexible, having alternative ways to conceptualize one's experience, which requires a greater level of control to appropriately regiment these options.

However, given the explanatory relevance of the topic of the development of control in cognitive development (Zelazo, 2004)—which goes beyond simple dichotomies—this general connection between greater representational flexibility and increased need for control is not enough. As a matter of fact, the very notion of executive function is ill-defined, covering abilities that make independent, purposive, self-interested, and socially responsible behavior possible (Lezak, 1995). In this regard, we will adopt here the psychometric proposal developed by Miyake et al. (2000), according to which three major executive functions can be distinguished: inhibiting, set shifting (or flexibility), and updating and monitoring the working memory. Therefore, we will try to review evidence that connects the development of these functions to language mastering. Such evidence can be found in three different areas of research: first, in direct continuity with Vygotsky's theory, we will look at how it has been developed in recent years, specifically in connection with the role of so-called "egocentric speech" ("self-directed" speech, for a more proper term) in higher cognition. Second, we will pay attention to the link between development of relational complexity and development of executive control. Third, we will review the important work of Ellen Bialystok on the processual effects of bilingualism as a trigger for executive development. Consideration of these types of studies reveals

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that cognitive control is to be distinguished from behavioral control, and that it is particularly the development of cognitive control that is associated with language. Further evidence of such a connection will be presented in the last section: a study that demonstrates the link between language and cognitive flexibility, already quoted in the context of the presentation of the "language as modular interface" position.

It is worth remembering in this context that the expression "executive function" was introduced by Luria (1966) in neuropsychology, in the context of his development of Vygotsky's ideas on the role of language as a tool for cognitive control. This term has broadened to refer to all processes involved in nonautomatic processes (Duncan, 1986; Pennington, 1997; Welsh & Pennington, 1988; Welsh et al., 1991), such as planning, set switching, inhibitory processes (both cognitive and motor), and working memory. In fact, executive functions are heir to what nineteenth-century psychology called "the will." It has just been in the last decade that "conscious control" has reemerged as a legitimate term. Current models of executive function are still couched in information processing terms, such as Baddeley's "Central Executive" (Baddeley, 1996; Baddeley & Hitch, 1974) or Norman and Shallice's "Supervisor Attentional System" (Norman & Shallice, 1980; Shallice & Burgess, 1991), even if they are admittedly homuncular, in that they do not fully account for how these operations are carried out. Anyway, it is not our purpose here to offer a model of executive functions; the purpose is just to argue the case for the processual effects of language on cognition. Verbal minds are uniquely capable of intentional, strategic, reflexive mental processes.

7.1 Inner and Private Speech

Inner speech has long been associated with conscious control. The main reason is probably because of the association of inner speech with the experiences of introspection or reflection. We experience ourselves as agents, reasoning to make decisions, and very frequently some sort of soliloquy is involved during this reasoning process. However, the overwhelming evidence that most of our mental life takes place unconsciously (for a review, see Wilson, 2002), reinforces the need to go beyond the intuitive level of introspection and self-consciousness, because it might turn out to be unreliable. An important milestone on this topic was Vygotsky's work on private (or egocentric or self-directed) speech, in which he made it clear that it is a kind of speech that is not communicative, but is addressed to oneself. He also argued that it constitutes a developmental transition in the process of becoming conscious thinkers who are capable of inner speech (of talking to ourselves). In private speech, the thought structuring role of language can already be appreciated, so inner speech can be conceived of as the outcome of internalizing the symbolic practices language involves (Bogdan, 2000).

In her defense of the functional relevance of private speech, though, Ornat (1991) had to limit her review to the initial studies of the Soviet School. Some of them still deserve mention, such as Luria's (1959) demonstration of the role of private speech in the conscious control of motor action. In one experiment, he offered infants either an immediate reward or a greater reward if they resisted the immediate reward. Only children with linguistic abilities were able to inhibit the response to the immediate reward. Another study (Luria & Yudovich, 1956) considered a pair of twins of 5 years of age—coming from a negligent family and showing a clear developmental delay, both cognitively and linguistically (i.e., no symbolic play and no planning in games involving object manipulation). The twins were separated and placed in cognitively stimulating environments, but with linguistic training in just one of the environments. The twin in the linguistic environment showed a greater and faster cognitive progress. Sokolov (1972) also contributed evidence of the involvement of private speech in many tasks, such as in nonverbal reasoning and visual memory. He used a speech interference paradigm that has been updated in the last decade and has furthered his results: cognitive performance is reduced when language is engaged in a secondary task, thus indicating its involvement in normal performance of a single task. The functionalities that can be ascertained in private speech are presumed to provide the groundwork for metacognitive and self-regulatory abilities when it becomes internal speech (Zivin, 1979).

Some scholars have also tried to continue Vygotsky's (1934) pathbreaking work on egocentric speech and the transition towards inner speech: a sort of Egocentric speech is self-directed, public speech that precedes its effective internalization, at which point articulaten is supressed, becoming inner speech. Language is learned and used in social interaction, but—at around 4 years old—it also accompanies the child's activities, especially when they are challenging or problematic. Egocentric speech consists of instructions, descriptions of the situation, or recommended action alternatives spoken aloud by the child to himself or herself (Frauenglass & Díaz, 1985). Diaz and Berk (1992) researched egocentric speech, further developing the Vygotskian theory. Their findings include the discovery that the quantity of self-directed speech is the best predictor of success in a task (Berk, 1994; Berk & Gavin, 1984; Bivens & Berk, 1990). Egocentric speech also correlates with measures of cognitive maturity, such as use of cognitive strategies in problem solving: bright children are more prone to use egocentric speech. The difficulty of the task might also increase the quantity of egocentric speech (Behrend et al., 1989). Berk (1992) concludes that self-directed speech—either aloud or in silence—is a crucial cognitive instrument for tasks that require executive resources (those that for Norman and Shallice engage the Supervisor Attentional System), such as planning, inhibition, ones involving novelty, or when mistakes are made.

It is true that this school of thought has not offered a microgenetic model of the mechanisms that make this process—and its subsequent internalization—possible. As Vygotsky remarked (and Mead as well later on), a symbol has an effect—not just on the recipient but also on the sender—and it can thus be seen as a restructuring factor in a problematic situation. However, it is not clear how such speech is produced. The standard, mainstream, psycholinguistic framework postulates a previous propositional intention, so that egocentric speech would be the externalization of the conceptual understanding. Egocentric speech, from this standpoint, appears to be a side effect. What this line of reasoning overlooks, though, is the executive dimension of egocentric speech: the possibility that it is a form of mentally rehearsing available options through linguistically describing them. On the other hand, as already discussed in Chapter 3 during the discussion of the relativity hypothesis, the functional role of language in verbal tasks is irrefutable; hence, it should be indisputable that egocentric speech can be useful in verbal tasks. It is the connection between egocentric speech and nonverbal tasks, at the executive level, which is controversial.

In this regard, though, we can consider evidence coming from an area far from Vygotskian inspiration: that of implicit learning (Berry & Broadbent, 1984, 1987). Some tasks—those that require planning and explicit knowledge, even if they are nonverbal—can only be learned with verbal instruction and solved with concurrent (internal) verbalization, but others are mastered through practice, so that the subject is not able to make explain his or her skill. This approach supports a dual view of cognition—of implicit and explicit processes—with the latter somehow relying on language. Many studies have focused on such differences between implicit and explicit processing, but we will choose the important one by Kirsh and Maglio (1991) on players of Tetris, the videogame. It is a clear nonverbal, visuospatial video game, in which points are earned by positioning 3-D images of geometrical blocks of several forms in a compact way, as they are descending from the top of the screen with increasing speed. The player can move and orient each block, to decide its landing place. When a complete line of blocks is achieved, it disappears, leaving more space for the placing of more blocks. When the blocks accumulate over the whole screen, the game is over. Thus, the game requires fast decision making and fast block manipulation.

In their study, Kirsh and Maglio found that experts in this game play according to a double procedure: a fast system of pattern recognition (which recognizes typical situations in the game and triggers overlearned moves), plus an explicit set of general principles (such as "do not group blocks in the center of the line" or "keep it as flat as possible"). The role of such principles would be to guide the fast module in a preventive manner, to avoid "dangerous" situations; in other words, they do not operate after the fast module occurs, but before. Now, these principles are clearly "language-infected"; they take the form of classical protocols of players in any game, as explicit declarative knowledge. In contrast to chess, Tetris does not require instruction, so it provides an interesting setting for studying how such principles are abstracted first and put to executive use later.

In general, research on implicit-explicit processing kind presupposes some (implicit) basic cognitive ability in infants, required for language acquisition in the first place, and sheds light on how language supports explicit cognitive processes. The basic insight is that linguistic activity contributes to cognitive control, which is required for problem solving. What remains to be established in greater detail is how the link between implicit and explicit cognition is to be understood. Additionally, a nonhomuncularist account of cognitive control also needs to be developed.

7.2 Relational Complexity

Several Neopiagetian research programs, pay attention to domain-general cognitive changes, as a key to explain the developmental changes observed in different domains. Such changes are related to changes in executive function: in the degree of control and cognitive flexibility reached by the subject. They are used specifically for distinguishing between central and modular processes (Baddeley, 1992; Just & Carpenter, 1987). In particular, as anticipated in the introduction to this chapter, there seems to be a relationship between how complex the representations a subject may entertain are, and the degree of cognitive control he or she needs to operate with those representations (Kyllonen & Christal, 1990). Such a basic link does not necessarily entail a role for language in increasing cognitive control to deal with more complex representations. The question to address, then, is whether language does, in fact, have anything to do with this developmental process.

Two related proposals deserve attention to answer it affirmatively: Halford's "relational complexity" (Halford et al., 1998) and Zelazo's "cognitive complexity" (Zelazo, 2004; Zelazo & Frye, 1997). As already seen through Gentner's work, mental representations do not just represent objects (or substances) but may also represent relations among objects, or relations among objects and their properties, among other things. Relational schemas of growing complexity (measured by the number of arguments involved in their structure) can thus be distinguished: "A is greater than B" involves two arguments, while "John sent a gift to Mary," involves three. "John sent a gift to Mary greater than the one he sent to Jane," also involves a hierarchical structure. Relational complexity is not just a matter of number of elements to be kept active to carry out a mental operation but of the nature of the relationships among them. Infant development is characterized—at least in part—by the increasing degree of relational complexity of the mental representations infants are able to entertain.

For Halford, a minimal level of relationality can be established by the "reversal learning test": after learning a relation between a and b "put X to the left of Y" one is immediately probed to find out whether the reversed relation is also understood ("put Y to the left of X") (Bitterman, 1975). Notice that the examples of relational schemas are linguistic and that this type of test is a test of systematicity. For Halford, passing such a test involves a level of schema abstraction that characterizes higher cognition. But this does not happen until 24 months of age. The initial discriminative knowledge, revealed through habituation–dishabituation paradigms, is thought to be perceptive, nonrelational, and context-dependent. At about 12 months old, the idea of the permanence of the object is achieved, which requires a child to separate the object from the place in which it is found (Wellman et al., 1986): it is a sort of monadic representation, which is not properly relational yet. The relational ability develops at about 24 months, when basic dyadic relations ("bigger than") and proportional analogies are grasped (Goswami, 1992). Transitivity and class inclusion involve triadic relations, which are difficult for children under 5 years old. For Halford, transitive inferences ("John is taller than Mary; Mary is taller than Peter") require integrating the two dyadic premises into a single triadic one.

Thus, Halford proposes that increasing executive skills are due to changes in the complexity of the representations available. A similar proposal can be found in Zelazo's theory of cognitive complexity and control (Zelazo, 2004; Zelazo & Frye, 1997), but in this case development of cognitive control is related to increasing "levels of consciousness," understood as an increasing role for reflection in guiding one's behavior. By means of the "dimensional change card sorting test," a metric of executive development is established. In such a task, participants are shown two target cards (for instance, a green tree and a red car), and asked to sort a series of bivalent test cards (thus, green cars and red trees) according to one dimension (color or shape). After having sorted several cards, they are told to switch to a different game (shape or color). Regardless of which dimension is first used, 3-year-olds typically perseverate—staying with the rules of the initial game—even if they can correctly answer questions about the new rule.

This dissociation between knowing and doing is accounted for in terms of the "levels of consciousness" model. According to it, 3-year-olds consciously entertain the post-switch rules—they exhibit an understanding of the new task—but the previous rules—those used pre-switch—are still activated in working memory and guide sorting behavior. What is required is a further level of consciousness in which the child realizes that both sets of rules are active at the same time: one set as verbal instruction and one set as behavioral habit. This realization enables the child to actively decide that the new set of rules should guide the system on that particular occasion. When this new level of consciousness is achieved, a new representational format is also possible: one that integrates both sets of basic level rules (sort by color: green/red and sort by shape: tree/car) into a unique hierarchical structure of conditional rules (sort either by color or by shape). This stage is typically achieved at 4 years old, when the related perseveration disappears. Zelazo emphasizes the fact that this age is also when children begin to understand false belief, and he points out the executive requirements of false-belief tasks (an aspect that will reappear at the end of Section 7.3). What distinguishes his theory is the connection between these higher level representations required for control and reflexive consciousness. He also relates these levels of consciousness to the distinction between implicit and explicit processes: the explicit ones are those made possible by such higher level representations.

Now the question is: is there any evidence that this process of increasing representational (relational or cognitive) complexity—and the cognitive flexibility that goes with it—is somehow linked to language? Remember that relational terms were already found to have an effect on relational thinking (section 6.3.1); now the question is raised in general.

Halford does not pay much attention to this question, in spite of the fact that he appeals to linguistic examples to introduce his theory: he engages in the propositional analysis of language in terms of functions and arguments. In fact, the same gradation of relational complexity he mentions can be found in the development of linguistic production: from single words, to juxtapositions of two nouns, to "pivot" sentences, to single sentences, and, finally, to subordinate and passive constructions. A longitudinal analysis of linguistic development, to ascertain whether language development precedes corresponding levels of cognitive complexity, is required on this topic. Some evidence is already available, such as that presented in the previous chapter.

Zelazo, on the contrary, is well aware of the tradition that connects language with consciousness, and he places himself within it. Language is thought to be the driving force of the development of levels of consciousness. In particular, verbal labeling is the basic mechanism of reflection: by verbally labeling one's experiences, the latter become an object of consideration at a higher level of consciousness. Higher levels of consciousness are conceived of in terms of increased cognitive flexibility, related to having more abstract labels available to articulate one's thoughts and to being familiar with different perspectives to consider. To demonstrate this effect, Zelazo used the Flexible Item Selection Task (Jacques & Zelazo, 2001). During each trial of the task, children are shown three objects, with two of them matching in one dimension (color) and two in another dimension (size). Thus, there is a critical item which exemplifies both features and has to be paired with the other item when the participants are required to switch dimension. Children are asked to select one pair, and are then asked to make another selection. In this task, 4-year-olds still have difficulty in switching to the other dimension. But, if they are encouraged to label their perspective on the first selection ("Why do these two objects match?"), selection in the other dimension is facilitated (Jacques & Zelazo, 2005). Similarly, in the dimensional card sorting test, performance is facilitated if the child is required to name the card before placing it into the sorting box (Kirkham et al., 2003).

A particular area of further research in this regard concerns the notion of metarepresentation. Since Leslie's 1987 proposal of a decoupling mechanism as the key step for imagination and false-belief attribution, the connection between language and metarepresentation has been further explored (Perner, 1998; Sperber, 1996). Metarepresentation has also been connected to reflexive consciousness, which clearly involves higher order control. From the point of view of relational complexity (Halford, 1996), a metarepresentation involves a second-order hierarchical structure. In false-belief attribution, such a hierarchical structure integrates two binary representations, as the way to simultaneously hold two representations of the same object, each according to a different perspectives (Flavell et al., 1990). For Perner, controlled processes require an explicit representation of one's own intentions, plus the inhibition of rival action schemas (Perner & Lang, 1999). The kind of metaintentional representation suited for such a role is linguistic. The linguistic representation provides the right mode for self-control and self-regulation, given that it captures the content of the intention without the need to make explicit how such content is internally implemented, and in this vein it also explains the connection between will and consciousness (Debner & Jacoby, 1994; Jacoby, 1991).

This conclusion can further illuminate our discussion in the previous chapter of the de Villiers hypothesis concerning sentential complements and the need to pay attention to their semantic—not just their syntactic—dimension. It provides a particular example of a linguistic construction that makes metarepresentation possible. Such a representational vehicle may be required for sustaining two different representations of the same situation at the same time for processual reasons: otherwise one's own representation is preponderant and takes over. Again, control comes with the proper representational format.

7.3 Bilingualism and Cognitive Control

Up to this point in the text, all studies reviewed were concerned with the cognitive effects of speaking one language versus speaking another or versus not speaking a language. In this section, we will consider the important work of Ellen Bialystok on the cognitive effects of speaking more than one language, specifically from a developmental point of view (Bialystok, 1999; Bialystok & Martin, 2004; Bialystok et al., 2005; for a review of such work, Bialystok, 2007, 2009). The starting point is to realize that a bilingual person faces a control problem in using language: given that he or she has more than one knowledge system, he or she has to choose which system to use and must then prevent interference from the other system. Given the fact that bilinguals manage to achieve such control most of the time, it is legitimate to ask how they succeed. The question is whether this is a domain-specific, modular sort of ability, related to language switching only, or whether it is, rather, a general-purpose one that can transfer to other tasks requiring cognitive control. Bialystok's work provides evidence in favor of the latter view. Of course, a complementary approach to bilingualism could be carried out: to study how competent speakers of various languages think of the contrasting aspects of their languages to which the languages direct their attention.

While there is no consensus in psycholinguistics on how the bilingual brain organizes the two linguistic systems, there is no doubt that both are active even when only one of them is being used. This has been demonstrated with a variety of tasks, such as cross-language priming, cross-language Stroop interference, or cross-language picture naming (Hermans et al., 1998; van Heuven et al., 1998). Reliable interference effects from the language explicitly irrelevant for the task at hand have been demonstrated. Therefore, bilingual speakers have to control which linguistic system is in use and to prevent interferences from the other. Notice that conflict is inescapable, regardless of relativistic effects: even if a unique conceptual system is assumed, two lexical or syntactical alternatives are available, of which just one is to be carried out. Of course, if (some) concepts are language relative, choice of language may also involve a conflict at the cognitive level. But the question raised in this section is orthogonal to the "language as lens" dimension. Moreover, cognitive control is required on the spot, to monitor also whether and when a code-switch is in order, so that the formerly suppressed linguistic system can carry on. Given such constant practice in executive process, development of executive function may be stimulated in bilinguals. To prove it, evidence of more efficient executive processing and faster development in bilinguals than monolinguals is required; evidence of the slower decline of executive functions with aging also supports it.

As we have already mentioned, controlled processing takes a long developmental path, until children are about 5 years old and the frontal cortex has completed its growth (Diamond, 2002). To study this process, it is possible to keep the representational difficulty of a task constant while changing its processual demands (by introducing misleading information or sources of interference, by requiring further monitoring, or by asking for switching between tasks). Then, one could compare monolinguals and bilinguals on such tasks. A bilingual advantage is to be expected when executive requirements are increased, and it is what Bialystok found, even if bilinguals show inferior receptive vocabulary.

In an important study in 2004 (Bialystok & Martin, 2004), Bialystok and Martin used the dimensional change card sorting tasks introduced by Zelazo (Zelazo &

Frye, 1997), as reviewed above. In it, children are first asked to classify bivalent cards by one dimension (color), and are then required to do it by the other dimension (shape), which has the effect of reassigning cards to the opposite box from the one before. In a previous study, it was shown that bilingual children have an advantage over monolinguals with respect to this task by about 1 year (Bialystok, 1999). However, the task is a complex one, requiring higher level representation (the central aspect of Zelazo's approach), response inhibition (changing placement actions), and concept inhibition (resisting consideration of the previously relevant rules). While Zelazo views the latter two as a single type of representation—and as developmentally derived from the first—the very distinction between these two kinds of inhibition is important for our analysis in this chapter. Response inhibition concerns the ability to resist the preponderant response, which is caused by a motor habit or the previous motor action carried out. Within the context of the task, it refers to the already accomplished act of placing each card in a particular box. Conceptual inhibition—the second type of inhibition involved—is needed to resist selecting the previously relevant dimension (color), in order to adopt the new classification criterion (shape). It does not have to do with whether or not the individual considers the rules to apply, but rather has to do with properly selecting, encoding, and representing the relevant features of the stimuli, when other features are (by habit or previous practice) more salient. Notice that standard accounts of executive function do not make this distinction, instead describing a single inhibition capacity. As a matter of fact, the go/no go experimental paradigm has also been reframed as a "think/no think" one (Anderson & Green, 2001), as if the involvement of a bodily motor action were immaterial to the task from a processual point of view.

In order to assess which one of the three distinguishing factors is the one which explains the bilinguals' advantage, four conditions were created. While the hierarchical complexity and response inhibition to solving the task are kept constant, stimuli complexity was manipulated with respect to the number of dimensions involved and their abstraction. The first condition was considered the baseline and included a single perceptual feature. The second condition was the original task, involving color and shape. The third condition depicted color and object outline. The fourth involved the dimensions of function and location (inside/outside the house), a more abstract, relational property. Bialystok reasoned that if it is representational complexity that is the key factor, the effect should increase across the conditions. If the key factor is response inhibition, the effect should be constant. If cognitive inhibition is the key factor giving bilinguals an advantage, the effect will depend on the interaction between representation and inhibition requirements; given the extra difficulty of the abstract condition, no effect is to be expected in this case.

While participants in both the monolingual and the bilingual groups were comparable in several cognitive measures, bilinguals showed a selective advantage in the color/shape and color/outline conditions in the post-switch phase, thus providing support to the theory that cognitive inhibition is the key factor related to bilinguals' superiority: in the dimensional change card sorting test, the main difficulty lies in the successful redescription of the items—in order to apply the new rule—and it is with respect to this activity that bilinguals perform better than monolinguals. The effect, though, is restricted to perceptually salient dimensions, rather than to functional/relational ones. In the latter case, switching is easier because the target properties are easier to ignore. This later observation of Bialystok is remarkable because language labeling was required to properly deal with the cards in the fourth condition, given that no two cards were the same. In itself, this last discovery suggests that cognitive control is easier when it comes to linguistic labels: a notion consistent with the cognitive and behavioral flexibility of language.

In conclusion, control of attention and inhibition of misleading information develops earlier in bilinguals than in monolinguals, regardless of the task used to score them (see also Carlson & Meltzoff, 2008). Bialystok (2007) concludes: "[B]ilingual children have an enhanced ability to control the use of their knowledge in performance, especially where competing or distracting information must be resisted. The source of the advantage, on the present view, is the experience of controlling attention to the relevant language system in the face of competition from the other language, which is simultaneously active but irrelevant to the current language task. This experience boosts those control processes, making them more efficient for other uses, even nonlinguistic ones." (p. 215)

This difference, though, is one of precocity. But the claim that bilingualism influences cognitive control also suggests that bilingual adults should exhibit some sort of advantage over their monolingual peers. To demonstrate such an effect is difficult, because it requires overcoming the belief in the postulate of a fixed cognitive architecture, which has been a central part of the explanation of information processing in cognitive psychology. However, brain plasticity fits better with the idea of a cognitive architecture that is responsive to interactions and experience, and this kind of approach has already taken hold in the area of executive function (Posner & Rothbart, 2000). In particular, it has been shown that video game practice stimulates executive function (Green & Bavelier, 2003). Similarly, the executive requirements of bilingualism could also give rise to the executive advantage in bilinguals.

Two studies have addressed this possibility. In the first one, a Simon task was used. In this task, stimulus-response lateral compatibility is manipulated, so intentional control is required for accurate performance. Participants must first learn a pair of contingent associations: to press the right key if they see a red square and to press the left key if they see a green square. In the test phase, the target squares are presented either to the right side or to the left side of the screen. When the red square appears on the left, participants take consistently longer to respond to the color as required: this is called the Simon effect. Like the Stroop effect, it reveals an interference of irrelevant information. To respond accurately, participants need to inhibit the preponderant collateral response (the impulse to press the right key when the stimulus appears on the right) in order to attend to the relevant dimension, and to do so requires intentional control.

Bialystok compared a group of monolingual with a group of bilingual young adults in performing a Simon task under several different conditions (Bialystok, 2006). These conditions varied the amount of conflict and switching required to perform it. In addition to the classical squares tasks, directional arrows were also used. For squares, the main demand of the task is to keep the associative rule active in working memory (to remember whether it is the left or the right button to be pressed). Use of the arrows simplifies this—at least in the first round—because the subject presses the button on the side indicated by the arrow; since the arrow, itself, shows which side to press, the conflict reduces to the compatibility of arrow direction and the side of the screen. However, while arrows make the response easier when the arrow is congruent with the associated button, once the association is reversed the task becomes much more difficult. Regarding the switch part of the test, conditions were introduced that varied the number of intertrial switches for both tasks (squares and arrows). The more changes in instruction there were, the greater the processing demands, and the longer it took to complete the task. Whereas few differences were found between the performance of monolinguals and that of bilinguals on these two tasks across these different conditions, bilinguals were significantly faster when it came to one experimental condition: the more demanding arrows task.

A second study (Bialystok et al., 2006) used the antisaccade task, based on the antisaccade effect (Muñoz et al., 1998). The antisaccade effect requires participants to resist the automatic attentional orientation they experience in response to an unexpected light or noise—an effort that takes time—because it again involves resisting a preponderant response. Bialystok also used the phenomenon of following the gaze direction of pictures of eyes (Friesen & Kingstone, 1998). In this way, she combined two kinds of cues that elicit automatic gaze orientation: flashing targets plus pictures of eyes. In the first condition, a schematic pair of eyes looking straight ahead appeared on the screen, which became colored (either green or red). Half a second later, an asterisk flashed on one side of the screen. If the eyes were green, participants had to press the collateral button, while if the eyes were red, participants had to press the contralateral button. In this way, green eyes were prosaccade, while red eyes were antisaccade (consistent or not with the side of the flashing asterisk, respectively). In this condition, the red eyes stimulus is more demanding, because in order to respond correctly, spontaneous orientation needs to be inhibited. In the second condition, eyes appeared shifted, gazing to the right or to the left, toward the points where the asterisk could appear, thus requiring a greater demand on intentional resources for overcoming a misleading directional cue, in addition to the prepotent saccade, in the antisaccade condition. Both when green eyes gazed away from the flashing asterisk, and when red eyes gazed to the asterisk, increased conflict is generated. Again, a superior bilingual performance was found in the most difficult condition. This study also included a comparison of young adults to early aging adults (60- to 70-year-olds in the latter category). Older bilinguals were also faster than their monolingual controls, even in the antisaccade condition (red eyes stimuli). In the crossed eyes conditions, bilinguals were faster across the board, revealing a slowed cognitive aging process.

There seems to be reason to believe, then, that bilinguals develop cognitive control earlier, are better able to deal with demanding tasks, and start the process of cognitive aging at a later age. However, it has been alleged that Bialystok's evidence is not strong enough, given that the participants in her experiments are natural groups—formed around a simple feature—rather than randomized, so differences due to bilingualism might be smaller than differences due to many other possible factors. Additionally, her research has been criticized because her choice of executive tasks has mostly focused on inhibition, rather than including other executive functions (Daniels et al., 2006). To respond to this concern, a recent study attempted a complementary paradigm (Soveri, Rodríguez-Fornells & Laine, 2011). It employed multiple regression to find out whether the age of language acquisition of the second language (L2), age, and frequency of code-switching in everyday life (as measured through a questionnaire), predicted performance on a battery of standard tasks for measuring executive function (in particular, for measuring the three major functions: inhibition, updating, and set shifting).

A group of 38 Finnish–Swedish early bilinguals, of ages between 30 and 75 years, participated in the study. It included: a Simon task and an Eriksen flanker task (both involving congruent and incongruent stimuli position with respect to hand of response, thought to require inhibition); a spatial n-back task (in which participants have to remember where squares appear, thought to tap into working memory updating); and a number-letter task (in which stimuli are number/letter combinations, but depending on the position on the screen, subjects have to decide whether the number is odd or even, or whether the letter is a consonant or a vowel, thus involving shifting abilities). These were used to try to study bilinguals' executive advantage in a piecemeal fashion. Relevant dependent variables involved the Simon effect and the flanker effect (extra time needed in incongruent trials), the n-back effect (a combination of reaction time difference between having to remember two-back versus one-back stimuli, plus error rate differences in both conditions); and switching and mixing costs in the number-letter task. Switching cost refers to the extra time required for task-switching, when a number task followed a letter task, or vice versa; mixing cost refers to the performance difference between such mixed tasks condition and a single-task baseline (thus reflecting the effort of keeping both instructions active in working memory). Multiple regression analyses were performed, to determine predictive correlations of age, age of L2 acquisition, and frequency of linguistic code-switching in daily life, with such dependent variables. Main results were that the frequency of code-switching in everyday life predicts the mixing cost in the number-letter task (in an inverse relationship: the more code-switching, the less extra time needed in this condition), providing support to Bialystok's suggestion that bilinguals' superiority in cognitive control is related to the practice of code-switching. Age was also associated with both working memory updating and mixing costs, also providing support to developmental effects as anticipated. Measures of inhibition were not so correlative, but notice that in Bialystok's own studies, performance differences between monolinguals and bilinguals are dependent upon the complexity of the Simon task. Mixing costs are also thought to reflect a greater demand on sustained control processes than switching costs, which have been associated with transient requirements and so are less affected by age. Mixing costs are thought to reflect top-down conflict resolution when competing tasks are presented, a situation which resembles that which bilingual speakers use to monitor their knowledge systems and decide which to use. In summary, this new approach opens a path for a more detailed investigation of bilingualism's effects on executive functions.

Bialystok has also provided neuroimaging evidence of bilingualism's effects on cognitive control. Using magnetoencephalography (MEG), she compared monolinguals' and bilinguals' brain activations while performing a Simon task (Bialystok et al., 2005). While differences in reaction time were not significative, she found differences in the cortical areas involved: while monolinguals' activation centered on regions traditionally associated with conflict resolution, bilinguals' activation involved Broca's area, suggesting that bilinguals may be dealing with executive tasks in a different way than monolinguals, taking advantage of the functional organization developed for language management. Other researchers in neuroimaging have also explored the brain correlates of Bialystok proposal.

Now, this raises further questions: is there anything specific to language that explains the effects of bilingualism? In other words, could similar effects be achieved through some other means of double competence or is this specific to language? And, conversely, is it really a general effect, or is it a specific one, instead? On this latter question, the work of Agnes Kovács is instructive. She has shown that bilinguals do better at classical theory of mind tasks, involving false-belief attribution (Kovács, 2009). She compared bilingual to monolingual 3-year-olds with respect to false-belief tasks with differing inhibitory demands. Bilinguals outperformed monolinguals only when inhibitory demand was high, such as in the classical task. With regard to theory of mind, this result suggests that such a competence may involve several components, one of them being executive function. The standard test of false belief attribution requires the inhibition of one's own perspective of the situation in order to attend to that of the other (Carlson et al., 1998; Leslie et al., 2005). Kovács has also shown that implicit understanding of the "seeing/knowing" principle starts in the first year of life (Kovács et al., 2010). Regarding bilingualism, though, this result confirms that the boost in cognitive control of bilingualism is already manifested at 3 years old, and that it is not domain-specific, but shows up even in cognitive tasks widely considered to be modular and domain-specific (another reason to call into question the massive modularity view).

So, if the boost in cognitive control is a general effect, why is it that it has to do with language? Could it be that practice in some other form of task switching could have similar effects? A possible answer to this question is language-neutral: any activity that requires increased cognitive control may have general, transferable, permanent effects in cognitive performance. Thus, video game practice seems to have such an effect (Bialystok, 2006; Green & Bavelier, 2003). However, it could also be that language provides a tool for cognitive control, given its external/internal duality. This further consideration was also submitted by Bialystok herself, in relation to the increased metalinguistic awareness of bilinguals (Bialystok, 1993; Cromdal, 1999). Thus, bilinguals are superior to monolinguals in tasks such as grammaticality judgments, in which meaningful sentences contain syntactic errors or in which semantically anomalous, but syntactically correct issues have to be sorted out. Practice in monitoring and switching between linguistic codes has an effect on a person's very understanding of the codes themselves the kind of result that Zelazo's theory would welcome and explain in terms of higher level representation. This can be related to the development of metarepresentation and a higher awareness of the conventionality of the code ("this object can be named this way, but also this other way"). Or—at the very least—it can foster an integrative form of representation that allows for increased cognitive control and flexibility.

7.4 Altered Language, Altered Thought?

If language is intrinsically connected to cognition, the alteration of one faculty should have effects on the other; in general, altered patterns in language should go hand in hand with altered patterns in thought. In particular, what we want to consider in this chapter concerns whether alterations of controlled processing might be due to the impairment of the control function of language in inner speech. Schizophrenia and Williams syndrome deserve close attention with regard to this topic (aphasia is not equally relevant since aphasics were functionally normal well into adulthood, when the higher level of functional organization is already well established). An in-depth discussion of such syndromes requires a degree of clinical experience which I lack. What follows is no more than an amateurish approach to introduce some developments that deserve especial attention. Several proposals have tried to account for alterations of thinking—related to problems of control—in terms of problems in the process of internalization of inner speech.

Fernyhough, among others, has paid attention to auditory verbal hallucinations in schizophrenia (Fernyhough, 2004; Kinsbourne, 2000). Schizophrenia has been traditionally described as involving disorders of thought, which can manifest in pragmatic impairment of linguistic communication (Andreasen, 1979). Its resistance to a developmental explanation has made it appear to be an adult disorder of organic origin. In recent years, though, the field has moved toward a symptom-based approach to the psychopathology of schizophrenia (Frith, 1992), which has led to the consideration of auditory verbal hallucinations as a self-standing phenomenon of interest in itself. Within this new theoretical framework, Fernyhough proposes that such hallucinations can be accounted for in terms of an abnormal development of inner speech. His argument starts by noting the paradox of verbal hallucinations: an alien voice is heard as part of one self. Several theories have been proposed to explain this phenomenon, which involve some sort of impairment in the monitoring system that controls the initiation of intentional action (Frith, 1992; Hoffman, 1986) and ascertains whether the expected bodily feedback matches the anticipated effects of the intention, and then infers an alien source in the mismatch case. But these approaches involve an infinite regress, in order to check the voluntariness of the initiating intention in the first place. On the contrary, Fernyhough contends that verbal auditory hallucinations happen as disordered inner speech. He offers two possible processes that might account for the hallucinatory experiences. On the one hand, they could be due to a disruption in the internalization process: inner speech is thought to be dialogically structured, so that an alien voice is constitutively present in inner speech; if this process goes wrong, the alien voice is not turned into an alter ego, but is interpreted as effectively alien. On the other hand, they might arise from a reexpansion of the abbreviated character of inner speech; instead of its normal semantic abbreviation, inner speech might recover the phonological properties of public speech, thus being heard as external. In both situations, inner speech would lose its normal form and function, by recovering the characteristics of external speech, and it would not be recognized as self-generated in a stressful, cognitively demanding context.

In a more systematic way, Frawley (1997) has contended that several psychological disorders—which are characterized as problems of control, and typically involve pragmatic impairments as well—might also be accounted for in terms of a developmental disruption of the process of internalization required for inner speech. This process normally gives rise to the higher cognitive functions that involve voluntary executive control. He discussed Williams syndrome among other disorders, as a case of failure of reflexive consciousness, even if some level of linguistic competence is kept, which can be accounted for in terms of the developmental impairment of the inner speech for control (what Frawley calls "language for thinking," or for cognitive control).

Williams syndrome was highlighted by Pinker (1994) as positive evidence for the decoupling view of language. Following initial descriptions (Bellugi et al., 1988, 1991), Williams syndrome patients were presented as examples of impaired thinking without a correlative linguistic problem. The syndrome, due to a genetic alteration, was first characterized at the phenotypical level as an extreme mental retardation, but with linguistic communication spared. However, such initial characterizations were later revised, in order to include the complex dynamics of genetic expression during embryogenesis and postnatal development, which may give rise to a variety of developmental pathways and adult phenotypes (Karmiloff-Smith, 1997). These developmental pathways and adult phenotypes may also differentially affect language (Tassabehji et al., 1997) and its brain lateralization (Neville et al., 1993), even if the genetic alterations are the same. Syntax, in particular—claimed by Pinker to be spared—is greatly variable; William syndrome subjects may have problems of concordance, problems in sentence embedding processing, and problems in distinguishing transitive from intransitive usages. But their greater linguistic difficulties are pragmatic, related to perseverating during conversation, quickly changing the topic, not taking turns, so that they tend to be verborreic. In a study with Spanish subjects, deficits at the morphological, syntactic, semantic, and pragmatic levels were found, when chronological age was taken into account (Garayzábal et al., 2001). It is misleading, then, to conclude that language is independent of cognition on the grounds that a person with an intelligence quotient of 50 can communicate linguistically. It is truer to the facts to say that this person presents a mental age of 7 years, with corresponding deficits in controlled processing, as remarked upon by Frawley. In general, Williams syndrome does not fit into a view of development as the turning on (or off) of genetically specified modules, but rather fits into an interactivist view of development (Karmiloff-Smith, 1998). The interactivist view of development allows for functional modules as the outcome of a development process, plus some domain-general capacity for cognitive control, which may be impaired in the case of a Williams syndrome subject.

The conclusion of this chapter is not easy to sum up. We have reviewed several strands of research that connect language with increased cognitive control through different routes. The old James (1890) link of language and consciousness is still in the background, but new ideas have also been developed. Reflexive consciousness—instead of a general imagistic consciousness—is one of them. In addition, there are several ways to make it more concrete in representational terms (as the ones reviewed in the chapter: cognitive complexity, metarepresentation), which make it more clear that a linguistic vehicle of representation might be the key condition for the enhanced cognitive control characteristic of verbal minds. The association of pragmatic impairment with impairment of linguistic reflexive consciousness also reinforces this explanatory link. But we have also considered another way to address the question: by the boost in cognitive control derived from code switching in bilinguals. This other trend makes it clear that cognitive control doesn't just come about through language use, and that it is better thought of as a gradual capability which language, and language switching in particular, may foster.

8 Making Sense of the Evidence: Verbal Minds and a Dual Theory of Cognitive Architecture

In this final chapter, I will try to synthesize the broad range of evidence reviewed, in order to conclude in which ways language shapes cognition. Then, we will pay attention to alternative explanations that contend that, contrary to appearances, language does not play any such role, either because the evidence comes short of proving such a cognitive role, because no mechanism for such influence exists, or because there is a third factor that explains the correlations between language and cognition. While most of these considerations turn out not to be convincing, the point on mechanism really is important and it has not yet been satisfactorily addressed by current theories of cognition. Therefore, in the third section, we will pay some attention to how linguistic development may bootstrap cognitive development, as an illustration of a central process through which such influence may take place. Finally, we will discuss what sort of cognitive architecture can best accommodate the sort of effects and capabilities which make verbal minds unique. I will propose that a dual theory of cognition offers the most promising approach to a general view of human cognition which can account for the role of language in cognition.

8.1 A Robust Pattern in the Evidence

Given all the evidence we have reviewed, the case for the role of language in cognition seems well supported. Lucy (1996) distinguished three kinds of effects language may have on thought. First, language makes possible some cognitive abilities, as proven by the extra array of abilities verbal minds possess vis-à-vis nonverbal ones. Second, language may inform thinking by providing guidance, salience, and constraints to cognition, as proven by the effects of lexical and morphosyntactical differences among languages and the corresponding cognitive differences in their speakers. Third, language use within a community may facilitate certain patterns of understanding and valuation. The evidence available provides examples of these three kinds of linguistic effects on cognition. What remains to be established, though, is how such a relationship is to be conceived. Even views of "language as peripheral" concede an important role for language in cognition, as many of our concepts and our thoughts are linguistically transmitted and originated. Additionally, many of our cultural practices rely on linguistic communication, and many cognitive tasks are verbal tasks—that is, some kinds of cognitive processing rely on the

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activation of linguistic codes and representations. So even skeptics concede quite a lot: a recognition that—as argued in Chapter 2—does not cohere well with their basic conception of the architecture of the mind.

A general methodological pattern can be discerned in how research supports a cognitive view of language. A robust crosslinguistic difference is first identified: in preferred frame of reference, in spatial language, in color vocabulary, in time, in number, or in gender grammaticalization. Cognitive effects of such differences are searched for in nonverbal tasks. If found, a developmental approach is in order to find out whether there are universal inherent preferences in that area, or whether there are no early biases in infancy, thus supporting the idea of an enculturation process. Human, linguistically mediated cognition is then compared with that of nonverbal cognitive beings, to discover differences in flexibility, variability, and control. Further evidence may be found in developmentally atypical populations and in alterations in which both language and thought are affected. Even a neuroscientific approach can reveal the differential involvement of neural areas, independently known to be associated with language.

Such a pattern has already been applied in some areas, for example, spatial frames of reference, ontological categories, color terms, numerical cognition, time understanding, and gender terms. In some cases, an initial pattern—which may be shared with the hominid or mammal evolutionary lineage—may be linguistically reinforced. In others, no initial bias is found and cognitive development is prompted by linguistic usage: this is especially so for relational categories. On the other hand, it is language which introduces the flexibility, the discreteness, and the abstraction of symbols in conceptual understanding. Language also seems connected with metarepresentation and cognitive control, even if the nature of inner speech is not yet fully established; in particular, the idea that natural language sentences are the very vehicle of cognitive representation is problematic. Inner speech as the interiorization of natural language may have different properties and may be seen as a "language of conscious thought" (Gomila, 2002).

We have also found that acquisition of relational terms facilitates relational projection of meaning, either by metaphorical understanding or by analogical reasoning. In several areas, such as gender, time, or number, we have found that relations in one area are used when thinking of other areas of experience, but not at the individual level: the social experience is received through the language. Language is not an inert symbolic code, but the heritage of social experience. This pattern of research has provided strong evidence for the conclusion that the remarkable peculiarities of verbal minds have much to do with their being verbal.

Finally, we have also considered evidence that suggests that linguistic structures provide the groundwork for higher level cognitive structures—that some contents are only accessible with the right representational vehicle, the mastery of which depends upon linguistic mastery. A stronger version of this point would be to claim that it is by being linguistic that the human mind becomes systematic and productive (Gomila, 2011). Again, such a view is not committed to the view that natural language sentences are literally involved in thinking processes. The proposal is rather that human thinking becomes systematic and productive when the recursive structure of language is internalized. Notice that this a recursive system of hierarchical dependencies is not just a combinatorial system: not all combinations are acceptable, even if they are interpretable. Such an achievement is not independent of cognitive development. The critical transition in syntactic development takes place from around 25 to 27 months of age (Barceló-Coblijn & Gomila, 2011; Corominas-Murtra et al., 2019; Ninio, 2006), and is driven by lexico-semantic development and linguistic exposition. Later stages in mastering recursive syntax—such as sentential complements—seem to have additional cognitive effects, in driving metarepresentational states in false belief attribution. Again, an alternative explanation which denies language any cognitive effect is possible, one that views all cognitive capabilities as innate, but then one has to ask why those higher level abilities just happen to manifest themselves when prompted by linguistic development. In summary, the evidence suggests that innate concepts in babies are implicit, while adult concepts are mostly relational, and explicit, and that this difference is due to a whole new range of cognitive processing possibilities, associated with becoming verbal.

Our current question, then, is to assess which of the theoretical positions outlined in Chapter 3 gets more support, and to discuss what kind of cognitive architecture is required to account for such a role. We will argue for a cognitive restructuring view, within a dual theory of cognitive architecture (in Section 8.3). Such a position also includes the claims of the "thinking for speaking" and the "scaffolding" positions, and disagrees with "language as modular interface" in the conception of the workings at the basic level, while agreeing on the executive impact of language. Linguistic relativism, though, is only partially vindicated: what really matters for the cognitive architecture is the effect of language over nonlanguage, rather than one particular language over another. The fact that language fosters flexible cognition runs counter to the determinism of an extreme Whorfian position. Languages are not inert symbolic codes, but lively ways of sharing social experience, and are thus open to innovation, according to social needs.

Thus, the sort of relativistic effects we have reviewed, in the "language as lens" chapters, due to lexical or morphosyntactic differences, come short of supporting a strong version of the relativistic hypothesis (Pinker, 2007). In most cases, speakers of a language are just biased toward the peculiarities of their corresponding languages, which might even require a long period of socialization before it appears (late infancy). This is consistent with the "thinking for speaking" approach. Even then, if required by the circumstances, people may be able to use nonlinguistically preferential ways of thinking: such as frames of spatial reference, spatial metaphors for time, or new ways of counting. The strongest relativistic effect found concerns the fixing of categorical bounds, which can be better interpreted as an indication of the differential nature of linguistically induced mental representation—as introducing discreteness within "the continuity of the mind" (Spivey, 2007; *see* Section 8.3).

Decoupling views of language, though, contend that the evidence is not enough—even for such mild relativist effects—and that positive evidence of the linguistic influence on perception and memory depends on verbal, rather than nonverbal, tasks. In fact, the decreasing performance of subjects in interference paradigms—in which participants were given a second, shadowing task—can be interpreted as revealing that participants are using verbal strategies to deal with those tasks. Thus, in comparative studies, either cognitive differences are denied, or they are attributed to the fact that participants carry the task set verbally (for instance, Carruthers, 2011; Munnich & Landau, 2003; Pinker, 2007). But this move can be considered unfair. If a nonverbal task—such as a perceptive discrimination one—is shown to engage linguistic representations, there is no better proof of the cognitive involvement of language and the difference between verbal and nonverbal minds.

The root of these dialectics, though, can be found, it seems to me, in a lurking underlying assumption shared by the opponents of a cognitive view of language: that nonlinguistic representational codes—assumed by everybody to be the foundation of prelinguistic and nonlinguistic cognition—are already propositional, language-like. In other words, the assumption is that mental representation remains the same before and after language. This assumption appears in how semantic development is conceived of by the decoupled view: it is assumed that conceptual development takes place first, from a set of innate conceptual primitives (Pinker, 2007). The proponents of the decoupling view also suppose that word learning is only the tagging or labeling of these already existing, independently grasped, concepts (Bloom, 2000; Pinker, 2007; but *see* his "bootstrapping" hypothesis for argument structure: Pinker, 1987, 1989). Some—or even many—concepts may lack a corresponding tag. The critical question, though, is the assumption that semantic development does not affect this nonlinguistic conceptual level.

This is wrong in general. We have seen that even for basic ontic distinctions—such as "individuals" contrasted with "substances"—prelinguistic conceptions are not precise and clear-cut, leaving room for a linguistic role in fixing such conceptions. At the very least, language acquisition influences the representational nature of thought because it provides cues about ways in which information can be organized and processed. The fact that verbal labels may facilitate memory for objects, but not memory for spatial configuration of objects (Simons, 1996) indicates that different kinds of codes are in operation.

On the other hand, the chapters on "language as tool kit" have made clear the influence of language in broadening and making more complex our representational capabilities, and the kind of cognitive control associated with them. They have not consistently established that such higher level thinking is only a sort of "talking to oneself," but they rather suggest that language acquisition is associated with a new representational level, at which the distinctive properties of human cognition can be found. Again, it is not that language creates cognitive control out of nothing; it is rather that it requires higher levels of flexibility and rule-following that go along with self-regulation and self-control in general, so that language might be instrumental in providing the representational vehicle involved in metaintentional states or "intentional ascent" (Bermúdez, 2003; Gomila, 2002). The "language as modular interface" proposal—especially in the Carruthers' version (Carruthers, 2006, 2011)—also emphasizes this executive dimension of higher order thinking, but its basic assumptions (massive modularity, cognitivism even at the basic level of cognition, inner speech as natural language sentences) have been shown to be problematic or not well supported.

As already insisted upon, no radical social constructivism is required to accommodate these restructuring effects. They can fit into a model which honors important innate predispositions, but which also pays proper attention to development as the key process for the configuration of the individual human mind (Gomila, 2010b). Such a view is also shared by the "social scaffolding" approach, but cognitive restructuring goes beyond "social scaffolding" in assuming that socialization is not just a matter of "contents" and external structuring, but also of processes: of ways of thinking, or of cognitive structure. Cognition is not conceived of as the unfolding of a genetically fixed plan in a particular environmental context, but as the outcome of an interactive process of self-organization. In summary, verbal minds are different from nonverbal minds—not because they include a further module (there are many kinds of nonverbal minds, which may differ in the set of their basic capabilities)—but because language generates a different dynamics of development, which brings about a qualitatively different mental setup. It is important to insist that it is not a mechanical model of deterministic, unidirectional causation that it is argued for. It is rather an interactive model of circular causation between linguistic and cognitive development, with dynamic effects, at any relevant timescale (Gomila & Calvo, 2008).

Despite this general pattern of research—which strongly suggests a cognitive restructuring role for language, as argued—it is still possible to resist such a conclusion in a reasonable manner. In fact, two argumentative strategies deserve consideration:

a. the theory of cognitive restructuring is defective as it is; a plausible mechanism for the constitutive role of language in cognition is required; and
b. the apparent correlation between language and cognition is due, not to a causal effect of language on cognition, but to a third factor which influences both language and cognition.

We will discuss them in turn.

8.2 Looking for Mechanisms

A proposal of structural enrichment in cognitive development—such as the one defended here as being most supported by the facts—has to address the challenge of specifying a plausible mechanism by which language may have such an effect. For both rational nativism and the massive modularity of mainstream evolutionary psychology, this is not going to be possible, given their common commitment to nativism and cognitivism. Anything that resembles Piagetian stages of development is deemed to be unacceptable. Their common effort is to try to show that much of cognition is innately specified, and—accordingly—their research program consists in trying to provide evidence of an "earlier in development than previously believed" cognitive achievement. Despite their efforts to dismisse it, though, development is the critical phase in the configuration of the mind, as argued in Chapter 2.

Thus, for instance, it has been argued that metarepresentation cannot be a cognitive achievement facilitated by linguistic development (Cosmides & Tooby, 2000; Sperber, 2000) because metarepresentation is taken to be a basic component module of the innate cognitive architecture, required for language acquisition in the first place. Assuming the Gricean program (which we have also criticized for overintellectualizing linguistic communication) linguistic meaning requires higher order intentions in the first place—including the intention that the audience will recognize the intention of the speaker to transmit her thought by using these words. If that were true, then, a sophisticated capacity for propositional thoughts and for metaintentional states would be needed to start understanding language in the first place, but we have no evidence of such capacities in the first 2 years of life. That's why the idea of an implicit theory of mind has gained support (Gomila, 2001; Reddy, 2008). In other words, it is just theoretical preferences, rather than proper attention to the facts, that motivates this "in principle" resistance to developmental enrichment of cognitive capabilities.

There is, however, the classical Fodorian argument against the possibility of concept learning (which we discussed and refuted in Chapter 2), which can also be deployed as a logical argument against the possibility of developmental enrichment of cognitive capabilities. This was Fodor's reaction to Dennett's proposal that language influences cognition by giving rise to propositional thought:

> *But we aren't told how an initially unsystematic mind could learn a systematic language, given that the latter is ipso facto able to express propositions that the former is unable to entertain. How, for example, does a mind that can think that John loves Mary but not that Mary loves John learn a language that is able to say both? Nor is it clear what could make language itself systematic if not the systematicity of the thoughts that it is used to express; so the idea that the mind learns systematicity from language just sweeps the problem from under the hall rug to under the rug in the parlor. On balance, I think we had better take it for granted, and as part of what is not negotiable, that systematicity and productivity are grounded in the 'architecture' of mental representation and not in the vagaries of experience. (Fodor, 1998, pp. 26–27)*

An analogous argument was used by the geology of the twenties of last century against Wegener's theory of continental drift: Wegener was accused of "solving" a problem—continental drift—by creating another one: the gigantic force needed to move the continents in the first place. So geology would be better off denying continental drift and assuming that the tectonics of plates are a constitutive part of the "architecture" of the terrestrial crust. In other words, Fodor's way of solving the problem of the systematicity and productivity of higher cognition is solved by making systematicity and productivity properties of all human cognition, in order to avoid the question of how higher cognition gets off the ground. The problem with this "solution" is that we don't have evidence that all human cognition is of the same kind (Gomila, 2011); we find many developmental transitions in infancy, and language seems to be associated with such transitions. At a minimum, a proposed solution should be able to acknowledge the facts in the first place.

Or, similarly, if Fodor's argument were correct, I couldn't learn to cut with scissors, because to do so I should already be able to use the scissors, and therefore, it couldn't really be learning. In fact, it is more appropriate to say that tools require practice because they involve new hand movements—new ways of sensorimotor coordination. Much the same is true of language: it is not suddenly acquired, it requires practice, and it involves sensorimotor coordination. Fodor's argument is driven by the intuition that the first language is acquired as a second language: by translating it into an already available language: the "original" language of thought. However, both scientific evidence and common experience show that infants learn their first language in a very different way from the way in which adults learn second languages. Just as spiders do not come equipped with a master plan of the webs they build—just with a basic set of operations—babies do not need the full complexity of language in the beginning. Complex structures may be the outcome of interactive processes. There is no need to suppose a perfect isomorphy between mechanism and behavior.

The weakness of Fodor's circularity argument for the claim that all concepts are innate lies in his assumption that the only way to explain concept learning is hypothesis formation and hypothesis testing. But it is not true that this is the only model of concept acquisition (Gomila, 2010a). Concepts may emerge out of interactive processes that generate a new organization, as we will show later in the chapter. Applied to functional enrichment, Fodor's argument is even more problematic, because functionalities are not supposed to be learned by hypothesis formation and testing. Babies do not learn to walk by forming hypotheses about how to distribute body weight, for instance. It is a matter of increasing coordination through practice, which—in the case of language—is socially shared. Hence, philosophical arguments cannot block the real question: whether or not preverbal and nonverbal minds are systematic and productive, and if not, whether or not they become so through learning a language. If that's the case, an account of such a cognitive restructuring is in order. Taking it for granted that all cognition is systematic because linguistic adult cognition is, is a *petitio principii*.

The question raised by Fodor, though, is still relevant. We have to explain "how an initially unsystematic mind could learn a systematic language, given that the latter is *ipso facto* able to express propositions that the former is unable to entertain." We have already insisted that the argument pressuposes that the only way for a conceptual enrichment is by conceived hypothesis formation. But this is not the only model of learning. Associative learning provides an alternative account of concept learning. And the distinction of the dual theory between implicit and explicit representation also offers a further explanation: "learning words provides explicit internal labels for ideas that were previously merely implicit, and this gain in explicitness has cognitive consequences" (Gentner, 2003, p. 225). Even within mainstream cognitive psychology, the powerful effect of verbal coding is well known (Miller, 1956): "the most customary kind of recoding … is to translate into a verbal code" (p. 89), at least with regard to cognitive economy and facilitation of several processes, including long-term memory or reasoning. So, which are the mechanisms by which cognitive systems get restructured?

The crucial function to describe concerns the development of word meaning. What needs to be proven is that language learning is not just in the business of tagging previously available concepts, but that conceptual development is driven by linguistic development (Carey, 1994, 2004). Additionally, it needs to be shown that linguistic development can change the initial, sensorimotor, and imagistic medium of the mental representation of a restricted implicit system into a more powerful explicit system. Lexical labeling, then becomes—not just a matter of tagging a previously and independently constituted symbolic concept—but labeling is just the way symbolic concepts are grasped. Verbal usage is part of the environment in which one makes sense of perceptual information and affordances. Several possible mechanisms—which have been shown to be relevant both experimentally and in simulations—might be instrumental in this process. Linguistic experience may become more salient than some environmental features, thus influencing early categorization; language may also induce increased similarity among the members of a linguistic category, discrete boundaries (categorical effects), and greater abstraction. Such labeling also facilitates control. Finally, there are the structural effects—the induction of propositional or conceptual thinking—that constitute the combination of such concepts into predicative structures (Bermúdez, 2003).

Such mechanisms have been demonstrated experimentally in a series of works by Lupyan (Lupyan, 2008a, 2008b; Lupyan et al., 2007, 2010). He has proven that lexical labels play a role in concept learning, by making it faster, making concepts coherent, reinforcing the correlative perceptual features that comprise the labels, and making them more discrete and definite, thus making their exemplars less memorable. Even in visual search, labels play a role in concept learning by facilitating visual processing of lexically homogeneous familiar stimuli, in what he has called "the grouping effect." This is especially so for highly variable categories, in which perceptual similarity of the member exemplars is small. But, in general, a label increases the internal coherence of a category, so that its members are considered to be intracategory more similar and intercategory more different, than they would be without the lexical label. In this way, the sharpness and the accuracy of the categorization are also improved. However, to accomplish this, some properties are highlighted while others are abstracted. Color might not be important for "chair," but it might be for "tomato." The more abstract a category, the more difficult it is to recognize particular exemplars. Hence, lexical categorization may come at the cost of greater recognition errors of particular members of the category. Labeling amounts to a representational shift: a different way to code the stimulus.

Simulation models of the interconnection between linguistic and cognitive development are also useful because they provide a clearer understanding of the mechanism by which such interrelation takes place. In particular, the models provide a clearer understanding of the shortcomings of purely nativist or purely empiricist theories of concepts. The model of Colunga and Gasser (1998) takes as its starting point the idea that categories are formed around strong correlational structure (the guiding idea of the Heider/Rosch prototypical view of concepts). Linguistic terms are modeled as part of the environmental structure, even if infants just become sensitive to them in their second year of life, after having already acquired some (nonlinguistic) knowledge of their world. Accordingly, if word usage strongly correlates with previously learned categories, correlative new words are going to be easier to learn than words that do not correlate. As a matter of fact, there is some evidence that lexical acquisition starts with nouns over verbs—even more specifically, "complete object" nouns over nouns for object parts—even though their frequencies are similar in speech (Gentner & Boroditsky, 2009), a fact that may be accounted for in terms of their higher correlational structure.

Colunga and Gasser also distinguish a second possibility of interaction, corresponding to the "thinking for speaking" view: linguistic use drives the infant's attention to some dimensions that are relevant to the language being learned, a bias that can show up in nonlinguistic tasks. A clear example of this is the shape bias, we have also reviewed. At around 18 months, children tend to generalize words to novel objects with the same shape, rather than size, color, or material, as the sample. But this bias just appears after children have learned about 50 nouns, most of them naming categories based on shape (Jones et al., 1992). It is not impossible for kids to learn other features—substance nouns are also learned—even if the ability to recognize perceptive properties, such as shape, color, texture, and material is basic and common. It is the language learned that drives how important those properties are going to be—just as the comparative evidence reveled—but it is also the function of relational terms to facilitate analogical reasoning.

A third, the most relevant, possibility is also suggested by Colunga and Gasser's model. It consists in the structuring role of language in cognition. It covers both the possibility that words may alter the previous nonlinguistic correlations found and the possibility that structure is found where was not a strong enough correlation structure. The result is that children develop new categories. An example of such a possibility is the fact that linguistic children essentialize natural kinds: believing that natural kinds involve an underlying essence that determines their natures, over shape or appearance in general (Gelman, 2003). This possibility amounts to going beyond perceptual properties as the correlation class when projecting linguistic meaning. It has been suggested that such a possibility can only rely on adult naming practices, which cannot be correlated with perceptual features only (Xu et al., 2005). Moreover, on hearing a new term infants expect it to correspond to an underlying essence that determines category membership.

Again, the use of social symbols "scaffolds" the children's cognitive development to make them social minds, to benefit from the accumulated wisdom of the group they are becoming members of. The significance of this possibility is that it supports a closer connection between communication and cognition than it is conceivable within the "language as peripheral" view. Making sense of one's world in cognitive development is much more difficult when it is done on one's own than when it is done in a social setting, so that one's conception of the environment is configured—not just by our personal interactions with it, but also with our interactions with others who already talk about it. To put it another way, concepts are grounded not just in perception, but also in shared linguistic use, which provides them their categorical, discrete structure. This is, in a nutshell, what Steels demonstrated for color terms (Steels & Belpaeme, 2005). His robots socially interacted in a certain environment, while playing a "naming game." Their models showed that neither the basic constraints of embodiment (the neurophysiology of color), nor the constraints of statistical structure in the environment are enough to account for a shared repertoire of perceptually grounded categories. The additional existence of a cultural community with names that denote categories is required. Again, this suggests that cognitive development is structured by language learning.

8.3 Could There Be a Third Factor?

According to this strategy to resist our conclusion, the multiple correlations between language and cognition that the literature illustrates are not to be explained in terms of a role of language in cognition, but are rather due to another factor, that simultaneously influences both language and thought. The strategy, then, consists in looking for a third factor, an intervening variable that can account for the correlation between language and thought. We have also to consider such a possibility, before making sense of the cognitive role of language in terms of a dual cognitive architecture. Of course, we can legitimately require some independent support for the alternative account, or we can discard it as a "just so" story if no independent support is provided.

Several candidates for such a third factor have been proposed, especially in the debate on frames of reference in spatial language and the apparent effects in spatial reasoning (Levinson, 2003), spatial memory (Feast & Gentner, 2007), the local environment (Brown, 1983; Li & Gleeman, 2002; Pinker, 2007), social structure (Lupyan & Dale, 2010); the habitual actions that go with each frame of reference (Glisten, 2002). All of them are environmental factors, and the common strategy in this regard is to contend that both language and cognition are molded by functional requirements: like in biological selective processes, language and cognition are thought to be molded by adaptive social and environmental constraints. It is convenient to bear in mind, then, that this strategy amounts to a different form of determinism, which again runs against the flexibility induced by language.

Thus, for instance, it has been claimed that living in an urban environment is different from living in a rural settlement, in the sense that the former people are more mobile, while the latter remain in a smaller territory; this is supposed to make the absolute framework more necessary for the first, which is then reflected both in language and in cognition (Brown, 1983). On the contrary, Li and Gleeman (2002) consider that a rural community is more geographically isolated and hence more likely to have an absolute frame of reference. In the case of the Tenejapa, Pinker (2007) contends that it is no wonder that the cardinal spatial terms are related to the slope of the mountain, given that the Tzeltal inhabit such an environment. But while any such suggestion may apply to one case, they fail in general, as it often happens with sweeping functional explanations. Thus, for instance, speakers of Tzotzil, another Mayan people also inhabiting a mountain slope, do not use spatial terms that imply an absolute frame of reference, but they use egocentric ones (de León, 1994). Surprisingly, Pinker interprets such a case as positive evidence for his geographical determinism. On the other hand, a multilingual comparison was carried out (Majid et al., 2004) of 20 languages, considering their preferential frames of reference and a series of candidate cultural factors, such as environment, rural or urban dwelling, and mode of subsistence. The only association found was between urban dwelling and use of a relativistic framework. In this case, though, the relevant factor that accounts for this association might be literacy, more common in urban habitats than in rural ones, just as we saw that the languages lacking the blue/green distinction are oral languages. But in this case, this does not challenge the linguistic effect; it just shows that literacy drives cognition toward increased diversification and complexity, again a linguistic effect.

With regard to action, it has been suggested that the differential use of frame of references in language and cognition might reflect differences in habitual patterns of action (Gallistel, 2002): different habitual actions involved in subsistence may be reflected in the preference of one frame of reference over another. For example, as we mentioned, long-range navigation without landmarks—be it terrestrial or maritime—seems to call for an absolute frame of reference. Similarly, we have seen that the development of a system of numerals is linked to the practice of counting, and we have also discussed the case of Oksapimin, in which the cultural change has driven the development of a system of numerals. Then again, other examples are not so easily related to cultural practices, such as the different spatial metaphors for time along different axes: back-past/front-future, back-future/front-past, and up-future/down-past. On the other hand, the culture cannot have an effect on its own: it consists of knowledge and practices that are also linguistically transmitted. It is also true that language is a composite of many different elements, which are variously used, according to pragmatic salience and social relevance. The point is that infants get exposed to cultural practices and actions by becoming competent language users: the linguistic meaning is connected to such social practices. Hence, this pragmatic dimension cannot be seen as independent of language, molding both language and cognition.

Another way to approach this issue is to consider the origin of linguistic differences. It is clear that they cannot be explained in cognitive or communicative terms: languages differ exponentially in the sort of elements they grammaticalize and the sort of aspects that are required to be coded, which can be rather arbitrary (think, for instance, of gender marking in inanimate nouns or of the lack of gender marking for animate nouns). However, it could be the case that language variation depends on some other factor not considered up until now. If that were the case, even if language may influence cognitive processing, language diversity might turn out not to be so arbitrary, after all. It might be that language diversity were the outcome of a glossogenetic process of borrows and transformations from earlier linguistic forms. Intriguing evidence has been recently published in this direction, which relates linguistic variability to social structure (Lupyan & Daly, 2010). By statistically analyzing the data of over 2,000 languages, they found strong associations between morphological complexity and some social factors such as number of language speakers, geographic spread and degree of language contact; namely, that languages spoken by large groups used to have simpler inflectional morphology than languages spoken by smaller groups. When such aspects of events as evidentiality, negation, aspect, and possession are considered, big linguistic communities tend to resort to lexical strategies, while small communities prefer inflectional morphology. This is a surprising result, because while it is clear that languages change, it is not so clear that they do so as a result of an increasing number of speakers, who, when taken individually, may not have a broader audience than speakers in smaller communities. The authors try to relate this trend to learnability considerations, again surprisingly, given the well-known fact that infants can learn any language. The very notion of differing linguistic complexity, as a function of inflectional morphology, seems problematic. At any rate, this does not amount to a case in which linguistic effects can be attributed to another factor: the trend is too general to account for the cognitive diversity found.

A different sort of consideration should also be considered: that both language and human cognition share the same structural system. This is the hypothesis of Chomsky's minimalist program (Chomsky, 2007; 2010) according to which language and thought share the same internal structure. A similar idea was formulated by Karmiloff-Smith (personal communication): that something happened in hominid evolution that made possible both language and higher level thought. Similarly, Penn et al. (2008) have proposed a discontinuity in hominid evolution, that would make *Homo sapiens*' cognitive capacities qualitatively different from those of the nonhuman primates; they suggest that this discontinuity is due to a representational medium for relational thinking. The problem with these views is that humans often are cognitively very similar to other primates; that's the case at least for the first years of life, up until language occupies center stage. That's why we think a dual architecture best fits the facts. Accordingly, the most promising evolutionary account is one that focuses on the coevolutionary relations between language, brain, and cognition (Deacon, 1997; Donald, 1991).

In this vein, Premack (2004) has suggested that language is just one of the factors that make human minds so unique. Other distinctively human abilities involve voluntary control of sensorimotor systems: imitation, teaching, and theory of mind. It is not clear whether these are considered independently necessary, jointly sufficient factors. Besides, it is not clear what individuating principle is followed, given that imitation, teaching, and theory of mind seem to converge into a single factor, a new form of social learning (Tomasello, 1999). Anyway, an evolutionary approach will reveal their mutual reinforcement relations.

Finally, it is also possible to argue that while language may play a relevant role in cognition, it is not the only factor to take into account when attempting to understand higher cognition. Thus, for Gentner (2003), what makes humans so smart is analogical cognition and language. We are similar to other species in associative categorization and statistical learning; our orientation and navigation abilities, and spatial memory, may even be poorer. We differ, though, in the ability to find analogies, to find relational isomorphies of increasing abstraction. For Gentner this is a genuine cognitive ability, quite independent of language (in fact, she submits that it could be contribute to language learning in the first place). So she thinks that language is a second factor contributing to our "smartness." She thinks of language as an external symbolic system, which augments our cognition in several ways: externally, it streamlines the developmental process, making it sensitive to the cultural achievements of each generation; internally, it provides tools for grasping, categorizing, and coding for higher order concepts: relational ones. Thus, both factors mutually cooperate, relational language prompting the development of relational cognition. In summary, for Gentner (2003) "learning specific relational terms and systems provides representational resources that augment our cognitive powers. On this account, language is neither a lens through which one forever sees the world, nor a control tower for guiding cognition, but a set of tools with which to construct and manipulate representations." (p. 223)

It could be argued, though, that the kind of analogical processing involved in language learning (in generalizing phonetic rules or grammatical patterns) cannot be the same sort of ability as the one Gentner's studies have focused on. The latter do not appear until year 4 (even if linguistic training in relational terms may accelerate the process), while if it was innate it should be in operation from very early on (such as in language). (This is a general complaint against nativist accounts of cognitive competences in general.) A possible strategy of reply is to split cognitive representation from executive control: the ability is there, but the resources of controlled processing that it requires are not yet: they take developmental time to mature. However, they are already there right from the start for language learning! A hypothesis suggests itself at this point: a core capacity for language learning is transformed once language is made available. An alternative option: language learning involves a kind of first-order analogical reasoning, which just requires that the same relation is found between different pairs of items. Second-order analogical reasoning, though, involves finding similarities between the (different) relations that hold among different sets of objects; or projecting the (abstract) structure that organizes a set of objects onto another set of objects, in order to make sense of them. The latter, second-order capacity might then be language-dependent, in the sense that it is only verbal minds that are capable of such cognitive achievements. But this is already the kernel of a dual architecture of the mind.

8.4 In Favor of a Dual Theory of Cognitive Architecture

Several researchers working in the area of the psychology of thinking have converged on the idea that human cognition can take place in one of two main regimes: we are capable of intuitive, fast, automatic, unconscious, implicit, parallel, associative processes, but we are also able of reflexive, slow, controlled, conscious, explicit, serial, rule-based processes. Thus, they propose a dual theory of cognition: in memory (Schater, 1987), in reasoning (Evans & Over, 1996; Kahneman, 2002; Sloman, 1996, 2002; Stanovich, 1999); in knowledge representation (Anderson, 1993; Dienes & Perner, 1999); in learning (Berry & Dienes, 1993; Reber, 1989); and in theory of mind (Gomila, 2001; Reddy, 2008).

The former processes are thought to be cognitively basic, evolutionarily ancient, and not easily controllable (for instance, by verbal instruction). The latter require attention and effort, take more time, and require conscious control. Thus, if we take the case of skill learning, we can distinguish low-level navigational abilities, such as crossing a street from high-level abilities, such as piloting a ship. The crucial question is how these two levels of cognition are related; in particular, do they exist alongside each other, competing for control? Or do they constitute separate systems within a common architecture? Even more fundamental: why is it that the higher level appears in development, if it is possible to succeed with the more basic one?

At the moment, there is no consensus on how to conceive of these two different systems or of their interrelation. The basic level can be seen as a collection of different modular systems of "core knowledge," while the other one makes flexible control possible by "broadcasting" the outcome of each of them to the whole system, making possible a flexible, increased control through mental rehearsal in inner speech (Carruthers, 2006, 2011; Frankish, 2004). But it is also possible to conceive of the basic level in interactivist, dynamic terms. The basic cognitive architecture involves language-independent perceptual categorization (which is applied to language learning to begin with). There are reasons to doubt that such basic capacities constitute symbolic, amodal concepts; they rather develop and differentiate as more or less stable attractors in a dynamic system of continuous processing (Spivey, 2007). From this point of view, there is no need for a language of thought to account for this basic cognitive level, which does not depend on the tokening of mental symbols, but rather on the activation of distributed, context-relative, coupled patterns of brain networks. Lexical labels do not create concepts *ex nihilo*; they rather transform those basic sensorimotor contingencies.

Human cognition, though, while it arises of sensorimotor, bodily interaction with the world, is not exhausted by it; or rather, part of this worldly experience concerns social symbols that can be internalized and that then give rise to symbolic mediators of such interactions. Higher cognition—the abstract, discrete, propositional, "controlled," and flexible form of cognition—seems to rely on such a mediation, which can be understood as a new level of cognitive organization. A cognitive function of language, then, can be to make cognition more abstract and more context-independent: more self-controlled.

The important point of consensus, then, for dual theories of cognition lies in viewing language as the critical development making possible this new level of cognitive organization. Thus, when we consider the nonverbal cognitive abilities of adult humans, we don't find much difference from the abilities of other primates. They all seem to use fast and frugal, unconscious systems (which can be called modules if such notion is weakened to the point of vacuity). Verbal minds, on the contrary, are something completely different: they are slower, purposeful, conscious, inferential, and flexible. It could be claimed that, through language, our minds become general-purpose, while animal minds are specialized (Premack, 2004). Humans can recombine mental elements, going beyond sensorimotor experience. While nonverbal minds can represent what they perceive, humans can represent what they imagine. Another way to describe this is to say that language provides propositional structure to thoughts, in a systematic and productive way. This amounts to a reversal in the direction of dependence between language and thinking proposed by Fodor, as already suggested. Thought becomes systematic through language, which makes a combinatorial system of representation with the "concrete infinitude" of language possible. Language also provides the mechanism of metarepresentation, which makes increased forms of control and flexibility possible. Language is clearly relevant for metacognition and for self-regulation in general.

Assuming a dual theory of cognition, two typical misunderstandings in this area can be avoided: that all cognition is language dependent if any is, and that language, itself, may be the representational vehicle of thinking. For a dual theory of cognition, it is just the higher level that is language-dependent; and this higher level is the outcome of the internalization of language, which is different of saying that we think in our language. We have also insisted that the effect of language is not just representational, but is also processual: it is connected to a new kind of cognitive control that has been shown to exist in many cognitive areas, according to a dual theory of cognition. Again, it is not claimed that executive control is made possible by becoming verbal, as if such control was an “all or nothing” capacity. It is rather contended that executive control is increased by language; the case of bilingualism’s effects on executive control nicely illustrates this increasing effect.

In contrast with other proponents of duality, I have suggested that the basic cognitive level is not to be viewed in classical cognitivist terms, but is rather to be viewed from a dynamical systems perspective. Hence, the conclusion is that language impacts our cognitive system by giving rise to a hybrid architecture, thus making systematic and productive, rule-based, inferential processes possible. In a way, though, this proposal shares the basic Fodorian architecture: modules plus a central system. It differs in that (a) modules are not conceived of in cognitivist terms, as symbol-crunching units, but in embodied, interactivist terms and (b) the central system is intrinsically connected to language. Against Carruthers, the central system is acknowledged as such, with no need for a weakening of the notion of module, as the level of integration and conflict resolution of all of the information available; it is not conceived of as relying on language as a representational vehicle, but of the propositional level of representation which language generates/activates.

8.5 Conclusion

In this work, I’ve presented the case for a critical role of language in human cognition, and I have discussed how to conceive of cognitive architecture to accommodate this role. I’ve tried to find grounds for a growing consensus in this regard, despite the still influential decoupled/peripheral view of language.

A linear view of causality, though, should be avoided: the way language shapes cognition is not at a stroke. Just like its evolution involved coevolution of other capacities (such as speech), language influences cognition in developmental interaction. It is also clear that language is grounded in sensorimotor and socio-communicative capabilities, which have to be language-independent, to avoid circularity. However, once this symbolic means is in place, those basic functions become transformed, both representationally and processually, in the direction of growing flexibility and complexity (as an example, think of communicative functions, such as indicative, imperative, or desiderative, which can be carried out by gestures, and how they are transformed when linguistic).

We have argued that language labels and transforms preverbal experience, in a way that allows for new forms of cognitive control. The evidence that language influences cognition, perception and memory, is now beyond reasonable doubt. While the new world of human experience brought about by language was never really disputed, it seems that it also plays a structuring role in human cognition.

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