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Chapter 10
Which Event Properties Matter for Which Cognitive Task?

Jean-Pierre Koenig, Douglas Roland, Hongoak Yun and Gail Mauner

Much of our everyday language use is concerned with describing situations, or what linguists call events and states. Verbs play a critical role in this endeavor, since they describe types or categories of situations (in this chapter, we only discuss events and event types). Speakers and comprehenders know a lot about each event type and much of this information is treated as mutual belief in the sense of Clark (1992). Both Speakers and comprehenders know that in describing a situation where a farmer is loading boxes of tomatoes onto a truck, it is felicitous to say that *the farmer loaded the tomatoes onto the truck,* whether the truck is full or not, but that one can only say *the farmer loaded the truck with tomatoes* if, as a result, the truck is completely full (e.g., Levin and Rappaport Hovav 2005). Thus, if a comprehender hears that *the farmer loaded the truck with tomatoes,* the comprehender understands that the speaker believed that the truck was full.

Comprehenders also have knowledge of what kinds of things are likely to be loaded by different people. Comprehenders are quicker to read *the truck* after *the farmer*

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loaded, and *the pistol* after *the assassin loaded* than the other way around (Bicknell et al. 2010). Comprehenders must, at some level, both represent the knowledge that there is a relationship between the syntactic structure used in describing the loading event and whether the action results in the truck being full or not, and the knowledge that assassins are more likely to load pistols, while farmers are more likely to load trucks.

Two important questions in the language sciences have been: What portion of this encyclopedic information is accessed and used during sentence processing? What portion of this information is relevant to the grammar of natural languages? An extensive amount of psycholinguistic research over the past couple of decades has shown that quite a bit of event information is relevant to online sentence processing. In contrast, only a limited amount of information has been found to be relevant to the grammars of natural languages. This contrast leads to the question of why the human parser and the human "grammar maker" seem to rely on different kinds and amounts of information. One possible cause for this divergence is that grammar development and language comprehension are carried out by separate systems that are sensitive to different types of information. This is typically cast in terms of speakers having a separate syntactic subsystem that is only sensitive to a limited set of properties of language (e.g., Pinker 1989). Another possible explanation is that grammar development and language comprehension are carried out by an integrated system, but the task demands of language development and the task demands of language comprehension are different. In this second view, the apparent specificity found in grammar learning is not due to limitations in what the system is sensitive to, but, rather, due to limitations in what information the system finds useful for the task it faces.

In this chapter, we first outline how grammars make limited use of our vast knowledge of events; we show that, grammatical systems that seem more "exotic" from the point of view of more well-known languages still make use of a limited set of properties—even if these properties are not the ones that are typically on the list of properties considered to be grammatically relevant. More importantly for the *why* question, we show that these "exotic" languages still obey the same design constraints as the more well-known systems; we then briefly report on some computational models of online reading experiments which demonstrate quite clearly that a distinct and much larger kind of event knowledge is used by the human parser; and finally, we propose an explanation for the difference in the use of event knowledge. In short, our explanation is that grammars and parsers use different kinds of event knowledge because the tasks listeners and grammar learners must perform are quite distinct.

10.1 The Grammar of Events Is Minimalist

10.1.1 Event Properties that Matter

Several aspects of the grammars of natural languages are sensitive to properties of events and their participants. (For ease of exposition, we sometimes will speak of

the *grammar of events* to mean the portion of the grammars of natural languages that is concerned with the description of events.) To name a few: the number of a verb's obligatory syntactic dependants (subject and complements), possibly, the frequency of occurrence of syntactically optional dependants, the grammatical function of these dependants (e.g., what is encoded as the subject or object of the verb), the case of these dependants (e.g., whether the subject, exceptionally, bears a dative case, whether the object, exceptionally, bears a genitive case), valence alternations (i.e., what distinct lists of dependants a verb may have), the mood of the head verb of sentential dependants (whether the head verb of an embedded clause should be in the indicative, optative, or subjunctive). Two patterns have emerged as linguists have investigated an ever-growing number of languages.

First, grammatical processes tend to target *semantically defined classes* of verbs, that is, verbs that share one or more event properties (Pinker 1989; Levin 1993, among others). For example, Pinker points out that the ditransitive construction in English, exemplified in *Mary gave Bill a book,* targets several narrow, semantically defined verb classes (e.g., verbs of future having such as *promise* and *bequeath*). More generally, the monumental work of Levin (1993) demonstrates that there is a close connection between valence alternations and semantic classes of verbs in English. Verbs that belong to the same semantic classes have the same (or very similar) sets of lists of dependants: Verbs that can both be transitive and intransitive, in both their middle and inchoative incarnations, occupy the same region of semantic space; loosely speaking, they are verbs that in their transitive variant describe externally induced changes of state, i.e., typically, changes of state induced by the referent of the subject.[1] When one looks beyond English, verb classes that are very similar semantically to the classes identified by Levin tend to recur as the target of grammatical processes, although not necessarily of the same kind of processes represented by English valence alternations. We illustrate this fact with a look at Hindi ergative case assignment in Sect. 10.1.3.

Second, the range of event properties that determine the encoding of a verb's dependants is very limited. Consider the properties of events that are relevant to linking constraints, i.e., the set of constraints that map semantic arguments onto grammatical functions (leaving aside whether these functions are primitives or derived from phrase–structural relations). The list in Dowty (1991) is fairly limited. The properties that affect the subject and object selection, respectively, are: volition, having a mental representation, causing an event, being in motion, and independent existence; and changing state, being an incremental theme, being causally affected, being stationary, and nonindependent existence. Other researchers might add a few properties, or subtract or rephrase others, but the list would not change much. Similarly, the list of event properties deemed by Pinker (1989) to be relevant to the determination of

[1] McKoon and MacFarland (2000) find corpus examples of verbs normally associated with internal causation appearing in transitive uses, but note of these uses that "if something is said to erode a beach, this cannot be just any something—not a person, not a shovel—it must be something that participates intrinsically in erosion, like wind or water." This finding furthers the notion that there are links between semantic properties and syntactic properties.

(narrow) verb classes targeted by valence patterns (e.g., the ditransitive construction) is quite small: state versus motion; path, direction, and location; causation; manner; properties or categories of the moving entity; temporal distribution; purpose; coreferentiality; and truth value. Again, other researchers might tweak part of this list or add to this list. Note that while some members of this list are potentially open-ended (e.g., manner or properties/categories of the moving object), this is clearly not Pinker's intention. In any case, what is consistent across authors is that the list of grammatically relevant properties is fairly small in comparison to the range of properties of events we know of.

Of course, one rather uninteresting possible explanation for the apparently limited range of grammatically relevant event properties is that linguists have not yet carefully examined languages with a more diverse range of grammatically relevant properties. However, we feel that this is unlikely to be the case. In the rest of this section, we present two case studies of apparently more exotic grammatical systems. Our conclusion will be that these systems are similar in critical respects to more well-known systems, and do not constitute exceptions to the pattern. Furthermore, our description of these less well-known patterns will highlight what we think are critical design properties of the grammar of events and help us understand why grammatically relevant event properties are so limited, as we discuss in Sect. 10.3.

10.1.2 Kin Terms in Oneida (Iroquoian)

The syntax of kin terms in Oneida (a Northern Iroquoian language) is particularly complex so we only focus on what is relevant to our discussion here (see Koenig and Michelson 2010, for details). A few forms will suffice to illustrate our point. Oneida, like other Iroquoian languages, marks its arguments on the verb or noun itself via pronominal prefixes. In the case of most kin terms, intransitive and transitive prefixes are used to mark gender, person, and number of the "subject" and "object" (agent, patient, and transitive prefixes in the Iroquoianist tradition). What is critical for our purposes is the rules that determine which argument of the kin relation denoted by a kin term is the "subject" and which is the "object." To avoid prejudging this issue and because determination of the "subject" and "object" of the kin term is orthogonal to determination of the term's referent or index, we name the kin relation by listing the members of the relation, and underline the member of the relation that corresponds to the kin term's referent. Thus, *mother–child* stands for the kin relation that holds between a mother and a child when the child is the kin term's referent, while *mother–child* stands for the kin relation that holds between a mother and a child when the mother is the kin term's referent. Crucially, in Oneida, whether one uses the root that is chosen to talk about a mother, *nulhá,* as in (1), or the root that is chosen to talk about a child, *yʌha,* as in (2), the "subject" always corresponds to the older-generation kin and the "object" to the younger-generation kin. (Transitive pronominal prefixes encode both the "subject" and "object" of a stem. The gloss *3ZOIC.SG > 3MASC.SG* indicates that the "subject" is third zoic singular and the

"object" third masculine singular). The rule in (3) accounts for the "subject" selection of most kin terms in Oneida.

1. lo-nulhá·
   3ZOIC.SG > 3MASC.SG-mother.child
   "his mother"
2. luwa-yʌha
   3FEM.SG > 3MASC.SG-mother.child
   "her son"
3. "Subject"-*selection rule 1* (refers to *generation*): The argument that corresponds to the older generation maps onto the "subject," while the argument that corresponds to the younger generation maps onto the "object."

Rule (3) is inappropriate for a few kin terms, in particular for the root—*ʔkʌha*—"sibling." In this case, the "subject"-selection rule must refer to age, not generation. As (4) and (5) indicate, siblings do not differ generationally, but whoever is the older sibling must be the "subject" and whoever is the younger must be the "object." Rule (6) accounts for the "subject" selection of—*ʔkʌha*—and a couple other stems.

4. lake-ʔkʌha
   3MASC.SG > 1SG-sibling
   "my older brother"
5. khe-ʔkʌha
   1SG > 3FEM.SG-sibling
   "my younger sister"
6. "Subject"-*selection rule 2* (refers to *age,* not generation): The argument that corresponds to the older person in a kin relation maps onto the "subject," while the argument that corresponds to the younger person maps onto the "object."

Rules (3) and (6) are "exotic" and differ markedly from traditional subject-selection rules or linking rules. In that sense, they may challenge Pinker's (1989) claim that linking rules are "quasi innate." But, they share crucial properties with other linking rules. Consider rule (3). It is not unique to Oneida, but seems typical of what Evans (2000) calls *kin verbs,* i.e., it is often found in languages in which kin terms are verbs (or, at least, partially verbs, as in Oneida; see Koenig and Michelson 2010). It is also operative, for example, in Ilgar, an Australian language. Although the content of rule (3) is unknown to nonkin-verb languages, its form is similar to that of the more familiar linking rules. More precisely, rule (3) is based on entailments of sentences that contain the kin term, and therefore applies to all pairs of arguments of the kin relation, as illustrated in (7); that being generationally older is what is relevant is shown by words for uncle and aunt, where generational order and absolute age order do not necessarily coincide; see Koenig and Michelson, op.cit.). Rule (3) applies no matter what properties particular mothers and children have; as long as there is a mothering relation, whoever is the mother will be the "subject," as she is generationally older.

7. For all **X** and *Y*, if MOTHER (**X**, *Y*), then **X** is generationally older than *Y*.

Rule (3) is also formally similar to many other grammar rules that make reference to event properties; namely, it applies to a semantically defined class of roots, kin terms. All stems to which rule (3) applies include kin relations in their meanings.

In contrast to rule (3), rule (6) also differs formally from less "exotic"-linking rules, in that it does not rely on a property *entailed* by the kin term. In other words, that one sibling is older than the other is a property of the individuals that are in a sibling relation, not a property of the relation itself. What is interesting, though, and confirms its oddity, is that the linking rule in (6) is an Oneida innovation. The term *ʔkʌha* used to mean "younger sibling," but came to mean just "sibling." At which point, the property became an incidental property of the fillers of the kin relation's argument positions rather than an entailed property of the relation. Interestingly, the property that determines the subject selection, being older, is still true of all the referents of the kin term's "subjects."

10.1.3 Ergative Case in Hindi

The purpose of linking rules, such as (3) or (6), is to map a word's arguments onto morphosyntactic positions (and, distinguish among arguments in so doing). They apply to all fillers of the argument positions. In some cases, though, the purpose of grammatical rules is to distinguish between different types of fillers. The conditions under which ergative case marking is assigned to subjects in Hindi will illustrate this case with another, apparently "exotic" set of rules (see Shakthi and Koenig 2009; Shakthi 2012).

Ergative case marking in Hindi is sensitive to the verb's aspect, a condition on ergativity that occurs in other languages. Thus, in (8), *Ram* is marked with the ergative case suffix *-ne,* because the main verb is in the perfective, but not in (9), where the verb is in the imperfective. The rule in (10) covers ergative case assignment when the verb is transitive.

8. Ram = ne ghar = ko banaa-yaa
   Ram = Erg house = Dat make-Pfv.M.Sg
   'Ram built the house.'
9. Ram ghar = ko banaa-taa hai
   Ram house = Dat make-Impfv be
   'Ram is building the house.'
10. *Rule 1*: If the verb is *transitive* and *perfective,* the subject is assigned *ergative* case.

Although still sensitive to the verb's aspect, ergative case assignment when the verb is intransitive is subject to additional, more "exotic" conditions illustrated in (11) and (12).

11. Ram khans-aa
    Ram cough-Pfv.M.Sg
    'Ram coughed (without meaning to).'
12. Ram = ne khans-aa
    Ram = Erg cough-Pfv.M.Sg
    'Ram coughed (purposefully).'
13. *khaas* 'cough,' *chiikh* 'sneeze,' *bhauk* 'bark,' *ciik* 'scream,' *cillaa* 'yell,' *muut* 'urinate,' and *thuuk* 'spit'

Some of the verbs denoting bodily functions to which this rule applies are listed in (13) (overall, the rule applies to only about 25 verbs, as many bodily functions are encoded via nominal complements to a light verb). De Hoop and Narashiman (2008) suggest that the subject's referent must have acted volitionally when it bears an ergative case in (11) and (12). It is true that in most attested examples, ergative case marking indicates that the subject's referent performed a bodily function in a nonnatural way, that is, with a *purpose* distinct from the normal coughing, as in (11). But, some examples suggest that the "exotic" additional condition on the assignment of ergative case to the subject of intransitive verbs is somewhat more abstract, and cannot be explained purely as volitionality. Consider the attested example in (14) or the example in (15). The dog cannot, presumably, have the intention required to purposefully not bark in (14). Similarly, there need not be anything unusual about the urination in (15). Rather, it is surprising that everybody urinated at the same time. What seems to be common to all uses of the ergative with intransitive bodily emission verbs is that the action (or, rarely, inaction) was somehow unexpected. One would have expected the dog to bark, and one would not expect everyone in a crowd to simultaneously urinate. Similarly in (12), one would not have expected Ram to cough, given his health. We therefore propose the, for now, informal ergative case assignment rule in (16) to cover intransitive verbs.

14. court mein bahut log moujuud th-ee phir bhii kiisii par bhii *kuttee = ne*
    court in many people present be-Past.3.Pl still any on also *dog = Erg*
    bhauunk-aa tak nahii
    bark-M.Sg even neg
    "Many people were present in court but still the dog did not even bark at anyone"
15. kiisii *ek = ne* nahii *sab = ne* muut-aa
    any *one = Erg* neg *all = Erg* urinate-M.Sg
    "Not just one (person) but everyone urinated."
16. *Rule 2*: If the verb is *intransitive* and *perfective,* it denotes a bodily function, and the action is *unexpected* on the actor's part, then the subject is assigned *ergative* case.

Rule (16) is somewhat "exotic" when it comes to (ergative) case assignment rules; all the more so, since expectations are properties of propositions or situations and case assignment is a formal mark on a dependant of the sentence's head. But, the event property that is marked (being unexpected) is one which is not unknown in other parts of the world. Furthermore, although it is somewhat unusual for a case marking rule to be restricted to a class of verbs as restricted as bodily function verbs (see Malchukov 2008, for a cross-linguistic perspective), the sensitivity of grammars to semantically defined verb classes is well-known. As was the case of Oneida kin term linking rules, Hindi ergative case assignment rules may seem "exotic," but do not invalidate the overarching generalization that grammars are sensitive to a limited number of event properties.

10.2 Sentence Processing Is Promiscuous

In the preceding section, we have seen that grammars make use of a very limited set of event properties. Even in the more "exotic" systems, there seem to be strong constraints on the type of event properties that can influence grammatical systems. Properties that matter to grammar are still part of the meaning of the verb (where meaning is defined, traditionally, in terms of entailments) or part of the semantic contribution of the sentence's syntactic frame (e.g., unexpectedness contributed by the ergative case marking in Hindi) and apply to semantically defined classes of verbs. As mentioned in the introduction, online sentence processing is much more inclusive: Many kinds of event properties seem to matter to sentence processing (see, among many others, Spivey-Knowlton and Sedivy 1995; Tanenhaus et al. 1995; McRae et al. 1997; Altmann and Kamide 1999; Kamide et al. 2003). Kamide et al. (2003), for example, show that the semantic category of the agent affects listeners' looks to picture of potential patients. Thus, upon hearing *the man will ride...* while looking at a picture array that includes pictures of a biker, a girl, a motorcycle, a carrousel, and two other objects, listeners will launch more looks to the motorcycle than when they hear *the girl will ride...* immediately after hearing the verb *ride*. This result, and many other results obtained in the same so-called visual world paradigm, suggests that listeners integrate their knowledge of events (what bikers versus girls are likely to ride), information provided by the linguistic input, and visual information, to predict what the direct object of a verb will be (the object of *ride,* here). Clearly, listeners in Kamide et al.'s Experiment 2 must have used their detailed world knowledge of bikers and events of bikers riding to predict the category of upcoming constituents (i.e., motorcycle).

10.2.1 *Semantic Predictability Versus Semantic Similarity*

In this section, we want to present data[2] that show that sentence processing is sensitive to (1) the likelihood of a dependant of a verb's semantic category (what we call the *semantic predictability hypothesis*), and (2) the distribution in semantic space of

[2] The data presented in this chapter comes from a preliminary version of the work reported in Roland et al. (2012).

the possible categories of a verb's dependant (what we call the *semantic similari hypothesis*). Before examining each hypothesis in turn, we illustrate the hypothese on a couple of examples. Consider (17–18).

17. The aboriginal man | *jabbed* | the angry lion | with | a spear | near its prey.
18. The aboriginal man | *attacked* | the angry lion | with | a spear | near its prey.

The previous studies we cited suggest that how fast the region following *with* will b read depends on how likely or semantically predictable a particular instrument is i the scene being described by the sentence up to *with*. Thus, processing will be faste for *spear,* a very likely (predictable) instrument, than for the *hockey stick,* a ver unlikely (unpredictable) instrument. As a consequence, if the instrument that occu is equally likely for the event described by (17) as for the one described by (18) (e.g if the *spear* is equally likely for both events), we would expect reading times of th underlined region to be equal. But, as we show in this section, processing is sensitiv to an even subtler aspect of event knowledge, namely how many other semanticall similar instruments could have been the complement of *with* rather than *spear*. Mor precisely, the semantic similarity hypothesis is that differences in the distribution i semantic space of the likely instruments of *jab* and *attack* might affect processin of the same actual instrument, namely *spear*. Figure 10.1 illustrates this putativ difference between the range of instruments for *jab* and *attack:* Intuitively, likel instruments of *jab* (spear, sword, knife, fork, machete, etc.) are more similar to eac other than likely instruments of *attack* (spear, sword, knife, gun, rock, stick, etc because *jab* places requirements on the instrument (e.g., pointy, able to be held i hand) while *attack* does not (e.g., attacking can be done with words, nuclear weapon etc.). Thus, in processing a sentence with *jab,* listeners and readers would be able t predict more of the properties of the instrument than they would in a sentence wit *attack*. These properties, and the categories of instruments that have them, will b more strongly activated, facilitating the processing of the actual instrument, *spear*.

If our hypothesis is correct, reading times of the underlined region might not b equivalent in sentences like (17) and (18) despite the fact that the *spear* is an equall likely instrument of the events being described, because events of jabbing involv instruments that are more semantically similar to the *spear* than events of attackin do. In the rest of this section, we present data that show that semantic predictabilit and semantic similarity both affect the processing of instrument phrases of the kin underlined in (17) and (18).

To test the distinct contributions of semantic predictability and semantic similarit on sentence processing, we used the reading time data reported by Yun et al. (2006 Yun et al.'s study contained 32 declarative sentences that contained an instrumen *with* phrase such as (17) and (18). All sentences had the same syntactic structure an the instruments were carefully normed to be highly plausible in their sentential con text, although because we independently model the predictability of the instrument our results do not depend on the highly plausible instruments being equally plausi ble. Moreover, there was no correlation between reading times and occurrence o instrument prepositional phrases (PPs) with our verbs in the British National Corpus Hence, there was no syntactic expectation for an instrument prepositional phrase.

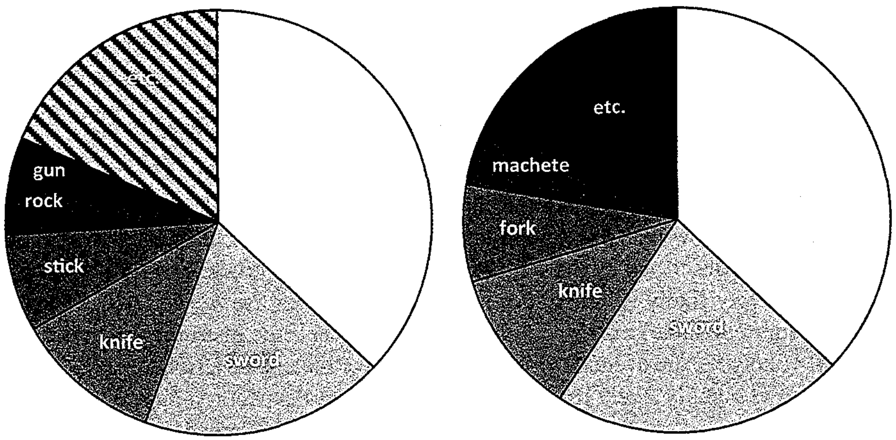

Fig. 10.1 Distribution of possible instruments of *jab* and *attack* in sentences (18) and (17) as determined by completion norming

Yun et al.'s study is particularly appropriate for our purposes because, although the instruments they used were highly plausible, the number and variety of plausible instruments varied across verbs. The semantic similarity hypothesis predicts that reading times for equally plausible instrument phrases will still vary if the distribution of plausible instruments in semantic space differs across verbs. For example, the range of instruments with which one is likely to jab a lion is smaller and more closely related semantically than the range of instrument with which one is likely to attack a lion.

We first measured how semantically predictable the instrument was for each verb. We then measured the distribution in semantic space of likely instruments for sentences such as (17) or (18). We then examined if there was a correlation between these two measures and the reading times for the underlined regions. We also examined whether combining the two measures increased the correlation, as an increase would suggest that semantic similarity has an effect on reading times beyond the effect of semantic predictability.

10.2.2 *Testing the Semantic Predictability Hypothesis*

The semantic predictability hypothesis holds that syntactic constituents whose meanings are more predictable, given the rest of the sentence will be easier to process, than constituents whose meaning is less predictable. In the case at hand, the syntactic constituents at issue are noun phrase (NP) complements to instrumental *with* and the part of the meaning whose predictability is at issue is the category denoted by the head noun of that NP (i.e., what kind of instrument was used to perform the action). We measured how semantically predictable an instrument was with three types of

completion tasks. The first task asked participants to fill in the blank in sentences such as (19). In the second task, another set of participants listed five possible things that could fit in the blank in sentences such as (20). The third task was a variant of Shannon's guessing game (Shannon 1951). Participants saw sentences such as (21) and had to guess the first letter of the word that followed *the*. If they guessed incorrectly, they were asked to guess again until they correctly identified the first letter of the word that followed *the*. Once they correctly guessed the first letter, they were then asked to guess the second letter, and so forth, until all of the letters in the word were correctly identified.

19. The aboriginal man jabbed the angry lion with _______________.
20. The aboriginal man jabbed the angry lion with ____ near its prey.
21. The aboriginal man jabbed the angry lion with the _______________.

We employed the results of these three completion studies to determine whether semantic predictability correlated with the reading times of the underlined regions of sentences like (17) and (18) in Yun et al. (2006). We first correlated reading times with the percentages of times participants completed the sentence in (19) with an NP that contained the instrument used in the online study. We then correlated reading times with the percentages of times the instrument was mentioned first. Finally, we correlated reading times with the percentage of times participants in our Shannon game task guessed correctly the first letter of our online study instrument. If semantic predictability of the filler of an instrument role affects processing of a phrase describing that instrument, we expect reading times to be negatively correlated with our various measures of semantic predictability. All correlations were significant and in the correct direction, that is, there was an inverse correlation between semantic predictability and reading times, as shown in Fig. 10.2. We conclude that how semantically predictable a particular instrument is affects how long readers will take to process a noun phrase that describes that instrument, even when the presence of an instrument is not necessarily expected, as it is rarely expressed.

10.2.3 *Testing the Semantic Similarity Hypothesis*

The semantic similarity hypothesis holds that the more semantically similar likely fillers of a participant role are (e.g., instruments), the easier it will be to process a constituent whose denotation bears that role (e.g., the NP complement of an instrumental *with*). In the case at hand, the fact that the likely instruments of jabbing in (17) are more similar to each other than are the likely instruments of attacking in (18) means that the underlined phrase in (17) will be easier to process than the underlined phrase of (18). To determine if semantic similarity affected processing, we compared the semantic similarity of the target instrument used in Yun et al.'s online study with sets of instruments listed in the first two completion studies we just mentioned, i.e., the study in which participants finished sentences such as (19) with a single NP and

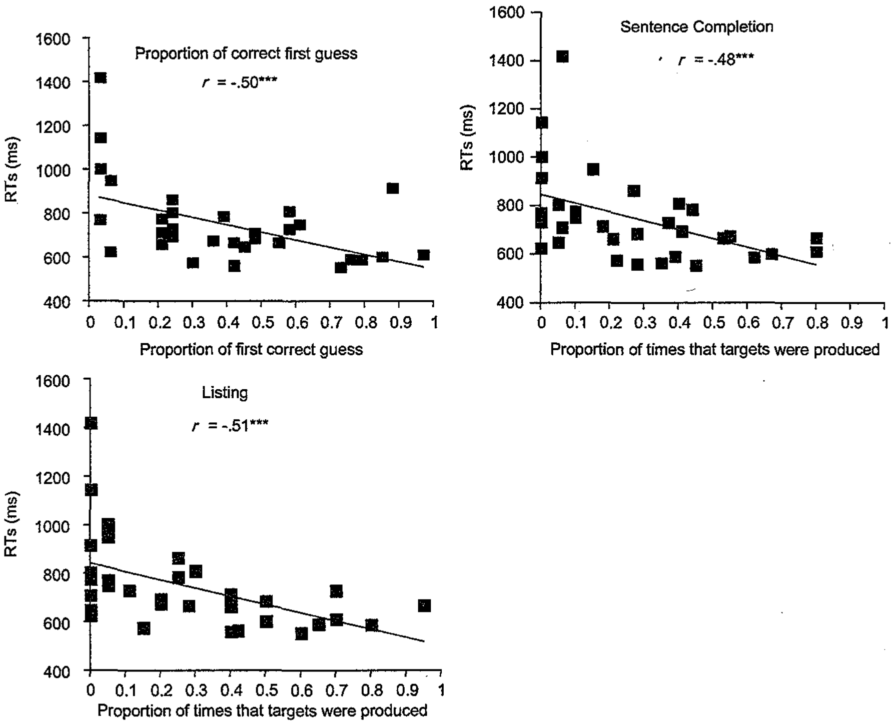

Fig. 10.2 Correlation between Instrument reading times in Yun et al. (2006) and various measures of semantic predictability

the study in which they filled in the blank in sentences such as (20) with up to five instruments. We used two measures of the semantic similarity of our target instruments with the two sets of instruments generated by participants in these two studies. The first measure employed latent semantic analysis (Deerwester et al. 1990), a measure of semantic similarity derived from corpus word co-occurrence information. The second measure computed similarity between the instruments using information contained in WordNet. (We used various measures of WordNet similarity. They all lead to similar results. We report results based on *vector pairs* similarity, Patwardhan and Pederson 2006.) As in the case of semantic predictability, the shared semantic similarity hypothesis predicts that reading times of target instrument NPs will be inversely correlated with the similarity of those instruments with the sets of instruments generated in our two completion tasks. In other words, the more "friends" (i.e., semantically similar) our target instrument NPs have, the easier it is for participants to process them. Figure 10.3 indicates that there was indeed a negative correlation between reading times and our two measures of semantic similarity.

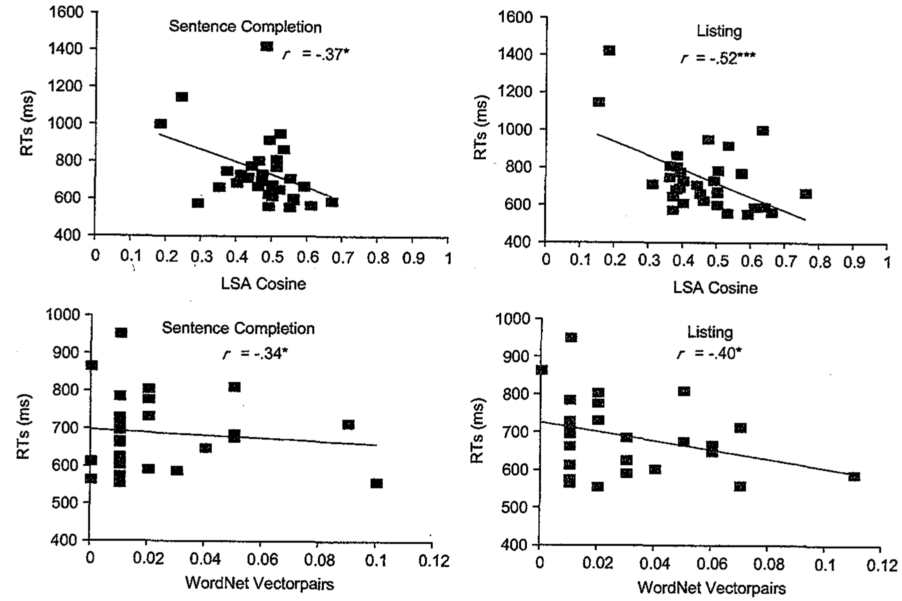

Fig. 10.3 Correlation between Instrument reading times in Yun et al. (2006) and LSA and WordNet measures of Semantic Similarity

10.2.4 Is Semantic Similarity Truly Different from Semantic Predictability?

Like semantic predictability, the semantic similarity of contextually likely instruments eases the processing of an expression that describes that target instrument. But, is semantic similarity different from semantic predictability or are they underlyingly the same? To answer this question, we need to assess whether semantic similarity makes a contribution to the ease of processing instrument denoting expressions that is distinct from that of semantic predictability. We constructed three distinct models: the best model for predicting reading times from semantic predictability, the best model for predicting reading times from semantic similarity of likely instruments to target instruments, and a model combining each of the separate best models. If both semantic predictability and semantic similarity make separate independent contributions to the processing of expressions describing target instruments, then the combined model should be better than models that include only semantic predictability or semantic similarity. The best model of semantic similarity used the number of tries to guess the first letter of the target instrument in the Shannon guessing game study to predict reading times of the instrument NP. Its R^2 value was 0.33. The best model of semantic predictability used the LSA cosine for the similarity to target instrument of the sets of instruments listed by participants in our second completion study to predict reading times of the instrument NP. Its R^2

value was 0.22. A combined model that included both factors had an R^2 value of 0.4. This suggests that both semantic predictability and, crucially, semantic similarity between possible instruments and target instruments play a role in the processing of target instruments denoting NPs.

It should be clear that the event properties that underlie semantic predictability and semantic similarity are not the kinds of properties grammars are sensitive to. We only consider semantic similarity here, for reasons of space. What our computational modeling studies show is that listeners and readers are sensitive to differences in distribution in the semantic space of likely instruments for particular situation types. What matters are differences in the similarity of various instruments with which, for example, one can jab or attack an angry lion. Instruments likely to be used to jab an angry lion share more properties than instruments likely to be used to attack an angry lion. This level of detail in event knowledge is never referenced by grammatical rules, no matter how "exotic" they are. But, why?

10.3 Two Distinct Cognitive Tasks

Pinker (1989) proposes the following explanation for the difference in range of event properties that are relevant to human cognition in general (and the human sentence processor, it seems) and grammar:

> Perhaps there is a set of semantic elements and relations that is much smaller than the set of cognitively available and culturally salient distinctions, and verb meanings are organized around them. Linguistic processes (...) would be sensitive only to parts of semantic representations whose elements are members of this set. (p. 166)

Pinker strongly hints that the human linguistic abilities are innately attuned to this set of semantic elements. If this were the case, it would explain why grammar rules cannot "see" differences among verbs other than the ones we mentioned in Sect. 10.1. Pinker refers to the fact that grammar rules cannot see much of our knowledge of events as its *color blindness,* because properties such as the (typical) color of participants in the described event are among the set of properties that grammatical rules are *not* sensitive to. According to this view, the difference between the semantics of grammar and the semantics of language processing lies in which information is visible to each system. If grammars were truly color-blind, it would also explain Pinker's main concern—children's ability to quickly learn valence alternations, as this limited vocabulary for grammar rules would limit children's hypothesis space when learning valence alternations. We cannot exclude Pinker's hypothesis, particularly in its strongest innateness form, as it is hard to imagine data that could falsify it. However, it is also possible that both grammar and language processing are sensitive to the same diverse range of information, and that the observed differences are due to the different demands of language acquisition (grammar formation) and language comprehension. In this view, the color blindness observed in language is the result of the language acquisition process (or at least the effects of a language going through multiple generations of the acquisition process)—not because the process is inherently insensitive to certain types of semantic factors (e.g., color) and sensitive to others (e.g., volitionality)—but as the result of an acquisition process that looks for correlations between the linguistic input and the situations where that input occurs and then makes conservative generalizations (rules) based on these correlations, such as the system described in Goldberg (2006).

To flesh out this point, we begin with a brief discussion of what the main job of the grammar of events is. Our basic insight is based on an "engineering" perspective—something like a very rough approximation of Marr's (1982) "computational" level of analysis. In other words, the question we are trying to answer is: What event properties should grammar and sentence processing pay attention to, given their function? The most efficient approach is for grammatical rules to only reference a limited amount of our vast knowledge of events. To see why, it is useful to consider, in broad terms, what the purpose of the portion of grammar that pertains to events is.

In broad terms, the function of grammar rules as they are written by linguists is to map the meaning of each of the possible verb lemmas in a language onto a syntactic structure. By syntactic structure, here, we refer to any or all of: structural configurations, ordered list of dependants, and case assignment to dependents, in languages where that is relevant. The number of possible verb lemmas in a language is fairly large. Raters in the English verbal lexicon survey reported in Koenig et al. (2003) and Conklin et al. (2004), knew approximately 4000 verbs. The average polysemy factor, or average number of senses per English verb, is between three (the Collins Cobuild dictionary) and four (WordNet). This means that college-educated American English speakers know between 12,000 and 16,000 lemmas. Alternatively, the number of possible subcategorization frames is fairly small. Using the old list of English subcategorization frames found in Gazdar et al. (1985) as a convenient approximation of the number of such "syntactic structures," this implies that grammar rules must funnel the semantic arguments (and possibly adjuncts) of 12,000–16,000 lemma meanings onto 27 subcategorization frames. Although the use of subcategorization frames of this kind is old-fashioned, and there are some frames missing in this work, nothing crucial hinges on our choice, as what matters is the approximate size of the syntactic distinctions grammar rules must effect. Assumptions about how grammatical rules work, we believe, would not be substantially altered if we had chosen another way of measuring the number of grammatical distinctions that must be made.

The grammar rules we describe in Sect. 10.1 shared two critical properties with more well-known grammatical processes. They were *type general,* that is, they applied to semantically-defined classes of situation types. They were also *token independent,* that is, they applied to all fillers of the argument positions of the relevant lemma's meaning. Token independence and type generality are "rational" properties to include in the design of any mechanism that maps over 12,000 lemmas (and countless tokens of the event type denoted by these lemmas) to a limited set of formal overt distinctions. In order to funnel 12,000–16,000 lemmas into 50–100 formal overt distinctions, verbs must be organized into groups. Consider type generality first. Here, we must map lists of semantic arguments onto subject and object positions or into

NPs bearing particular case marking for a certain set of verbs. There must therefore be a way to select the set of verbs to which a rule applies and reject the set of verbs to which it does not apply. Grammars, we know, use semantically natural event categories to select verbs and reject other verbs. In the case of the Oneida pattern, we discussed in Sect. 10.1.2, the targeted stems were those that denote kin relations. In the case of the Hindi pattern we discussed in Sect. 10.1.3, the targeted stems were those that denote bodily functions.

Let us consider token independence now and imagine that grammars are not token independent. For example, imagine that if one were talking about good food, then the constituent expressing the food would be a direct object, but if the food was not good, then it would be an oblique (or the reverse). Since the quality of what is eaten is not part of the meaning of the verb *eat* (it is not an entailment of the denotation of the filler of its proto-patient argument, to use linguistic jargon), this would require the mapping to subject/object position to differ with the tokens of eating one was describing. Speakers would then be required to pay attention to the properties of participants that may or may not be true of the token of the event type denoted by a verb (and which often would not be known to be true or not). Such token *dependence* would require us to retrieve, evaluate, or guess, information above and beyond the information that is a part of what defines the category of the event being described, information which speakers do not necessarily have at their disposal. Entailments, on the other hand, are guaranteed to hold anytime an event belongs to the category denoted by the lemma. By having grammar rules rely on entailments, speakers can know which rule to apply when using a lemma by virtue of accessing the meaning of the lemma (the event type or event category it denotes).

Not all grammar rules seem to target token-independent entailments of the lemma being considered. Consider the well-known English ditransitive valence alternation:

22. I gave Mary a book.
23. I sent Mary a book.

Whereas the fact that Mary is going to have a book at the end of the event is an entailment of *give* in (22), it is not for *send* in (23) (see Rappaport Hovav and Levin 2008). This is not only because of the vagaries of the post office, say, as we could use the notion of restricted entailment discussed in Koenig and Davis (2001), but because not all tokens of sending result in an (intended) change of possession. If the USA sends men to Mars, Mars will not, as a result, "own" the men. In fact, the use of the ditransitive (at least for those scholars who believe it always encodes an intended change of possession) is partly motivated by the desire to select the subset of tokens of sending that involve intended change of possession. Our proposal that linking rules must be token independent and type general can be extended to model these kinds of cases if we follow Goldberg's (1995) hypothesis that argument structure patterns are the structural equivalent of words and have meanings that combine with the meaning of verbs. Simply put, if the ditransitive pattern (however one chooses to represent it formally) is assigned the meaning of "(intended) transfer of possession,"[3] the semantic side of the ditransitive construction still obeys token independence, i.e., the meaning of the construction must apply to all tokens of lemmas that participate in the construction. A similar analysis can be given to the Hindi ergative case assignment rule we discussed in Sect. 10.1.3. Ergative case assignment to intransitive verbs in Hindi indicated that a particular token of coughing, say, was unexpected; but, of course, not all instances of coughing are unexpected. The use of the ergative case marker distinguishes unexpected tokens of coughing from expected ones in apparent violation of the requirement that the semantic property targeted by a grammatical process be shared by all fillers of an argument position. But, if we analyze ergative case marking on intransitive verbs describing bodily functions as a construction with a particular meaning, we can maintain token independence just like we did for the ditransitive construction: Unexpectedness of the action is a property of all tokens of the verb *in this construction*. There is certainly a "hack" flavor to this resort to constructional meaning. But, we think it does not deter from the general validity of the claim that token independence is a good design principle for the grammar of events, as not all constructions can contribute meaning in the way the Hindi ergative case marking rule does, i.e., some case-marking option must be available that does not add any meaning. If our analysis is on the right track, grammars target meaning of verbs, classes of meaning of verbs, or abstract meanings that are very general meanings of verbs (i.e., constructional meanings) and grammars look the way they do, because they target meanings. Token independence, then, properly understood, reduces to the fact that grammar rules target meanings (although not necessarily individual verbs' meaning).

Type generality and token independence are good design principles, given that event grammars need to map between 12,000 and 16,000 verb senses onto less than a 100 morphosyntactic distinctions. However, even if type generality and token independence constitute the best design for grammars, there must be a mechanism through which this design is implemented. It is beyond this chapter to do more than provide suggestive mechanisms that might be responsible for these observed constraints on grammar rules. A fairly simple assumption about the process of making generalizations during language acquisition could account for many of the observed properties of language, namely, the principle that generalizations are made over the largest coherent grouping. In other words, if a feature is true across several types, and the types form a coherent grouping, then the generalization will be made for the group, rather than at the level of each type. In this manner, if a set of event tokens describe by a verb or a series of verbs share a property, (e.g., the subject is agentive), and the verbs themselves form a group by virtue of having some other properties in common, then the generalization will be made at the level of the event type itself rather than a set of event tokens or at the level of the group of verbs rather than at the

[3] See Goldberg (2006) for the "abstract" meaning of argument-structure constructions and the fact that this meaning corresponds closely to the meaning of "general purpose" verbs like *put*, *give*, and so forth.

level of the individual verb. This tends to result in the features and the verb classes being semantically defined, because semantic features are more likely to be shared by a large set of verbs.

However, the relevant properties for grammar rules do not have to be semantic. Take for example the grammatical patterns observed in conjunction with the feature ± Latinate. Pinker (1989) and Grimshaw (2005), among others, have observed that most verbs of Latinate origin do not participate in the ditransitive alternation. Thus, despite the semantic similarity of *donate* and *give*, only the latter alternates. Alongside *John donated US$ 5 to the endangered species fund*, we do not have *John donated the endangered species fund US$ 5.* One plausible source of this particular behavior of verbs of Latinate origin is that they do not alternate in their source language (French). As authors have pointed out, what groups those verbs together for English native speakers ignorant of the stock of the verbal lexicon is most likely sound based. More generally, we surmise that semantic factors in grouping verbs that syntactically pattern together are most likely to arise within the development of a single language, but other features such as sound can come into play when two languages with different sound and grammar patterns interact (e.g., the way that Latinate features got into English).

Aside from rather rare sound-based generalizations of the kind found with verbs of Latinate origin (and most likely relevant only in the context of the presence of two lexical stocks within a single language), the fact that generalizations are represented at the level of the group of lexical items for which it holds results in the appearance of *type generality*—the observation that grammar rules apply to semantically defined classes of situation types. These principles operate at all levels of the acquisition processes from the acquisition of lexical meaning to verb selectional restrictions to grammar rules. If the learner was faced with an unusual language where each verb had its own unique mappings between semantic roles and case markings/word order, the learner would learn such a language, but at the expense of not being able to generalize from input to unseen verbs—as the relevant information would be encoded as part of the lexical entry of each verb, rather than at a higher level. However, a different result is more likely in such a situation. If a language started such that an *agent* was mapped to the subject for a random set of verbs and to the object for another random set, and the learner was actively trying to make generalizations across the input, any imbalance in the input (e.g., if a subset of words in early input favored an agent–subject mapping) would result in the learner "regularizing" the language.

We have just suggested that type generality and token independence (with our semantically potent constructions proviso) are good design features for the grammar of events and that the principle that generalizations are made over the largest coherent group of tokens and types makes it possible to "implement" a grammar that obeys these design principles. Is this enough to explain the color blindness of event grammars? Yes and no. Token independence and type generality are enough to explain why nonsemantically potent morphosyntactic constructions (i.e., constructions that do not add semantic information to that present in the verb's meaning) are color-blind. Color, size, odor, and countless other participant properties are excluded from consideration in generalizing over event tokens, because participants' color is not an

entailed property for more than a handful of verbs in most languages. So, whereas we have verbs like *redden* and *yellow,* abstracting away a class of event types into something like "changing color" would not be very useful, as it would select only a few verbs. Of course, one *could* imagine a language in which lots of verbs describe colors, changes of colors, and so forth, so that it may make sense to isolate this class of verbs by building in the semantic definition of the class something about color. But, known human languages do not have that many color-oriented verbs. For the same reason, type generality and token independence also account for the kind of semantically potent construction the English ditransitive valence exemplifies, to the extent these constructions' meaning correspond to that of "abstract" verbs. In other words, the types of properties that play a role in grammar rules tend to be semantic, and fairly abstract, high-level types of properties, because most grammar rules apply over large sets of verbs, and properties such as "volitional" are the only kinds of properties likely to be shared by all subjects of a large set of verbs. In contrast, a property like "green" is unlikely to be shared across all fillers of a single role for a single verb, let alone a large set of verbs.

But, our proposal does not as such explain the fact that there is no attested language that is just like Hindi, except that ergative case on the subject (or any other case marker) marks the subject's denotation as being, say, green. In other words, our proposal does not directly explain why the semantic contribution "unexpected action" is attested, but "green" is not. The absence of ergative-marking-green agent languages is not due to good design. It is due, we suggest, to the fact that an agent's color is not part of the causal structure of the world (what our conversations are often about) like volitionality is, or is unlikely to be relevant to a speaker's discourse goal (as signaling the unexpectedness of an action may be). In other words, the absence of ergative-marking-green agent languages is due to the causal or goal stuff the world and our discourses are made out: An agent's color happens to be irrelevant for them.[4]

In summary, ultimately, the explanation for why a larger portion of a language's lexicon is devoted to bodily emissions/functions than color changes is anthropological and is part of the substrate of grammars: What human beings are attuned to and why they develop categories of events they do. But, given that they do have a larger verbal vocabulary for bodily functions than color changes, the fact that grammar rules target classes of verbs that denote bodily functions is a simple engineering decision. You get more bang for your buck when trying to funnel a large set of lemmas into a limited set of formal distinctions.

Let us consider now what the human sentence processor does. Its role is to read the next word or phrase, access the relevant syntactic and semantic information associated with those words or phrases, and integrate this information with the syntactic and semantic representations of the already-encountered expressions. To perform this task, anticipating a part of the syntactic or semantic information of the next expression is quite useful. To that end, then, the processor will predict as many of

[4] However, if, for example, there were a culture where the color green was associated with that culture's supreme being, and all actions performed by green-colored agents were thus considered to be special, then we might expect that a separate case marking for green agents could arise.

the properties of the upcoming expression as possible; in the case of instruments, these properties would include semantic properties, since the usefulness of syntactic information is so limited in this case, as phrases encoding instruments so rarely co-occur with our verbs. Now, the kind of instrument that was likely used in an event does not depend solely on the meaning of the verb. There is no generic instrument we use. Different agents use different instruments on different patients for different tasks. One does not cut a nail with the same kind of instrument used to cut the lawn (one hopes). One does not spear a lion with the same kind of instrument as one debones a lion. So, in semantically predicting the instrument used in a described event, readers must conjure their beliefs about who uses what to do what—the complex set of beliefs that make up our understanding of tools. Of course, the predictions one makes take the form of a probability distribution. Given the event type denoted by the verb (*spear* versus *attack*), the agent involved (an aboriginal man), and the patient involved (an angry lion), there is a range of instruments that are more or less probable to have been used. If, as we suggest, readers activate instruments to the degree they are probable, given the event type, the agent, and the patient they have encountered, clearly, more probable instruments will be integrated faster, since they were more activated. But, more interestingly, the distribution in semantic space of probable instruments will affect reading times. This is because instruments that cluster together in semantic space share many features. High activation of any of these features, because it is borne by a particularly probable instrument, will, in turn, boost the activation of all instruments that share this feature—even the otherwise less probable instruments. The more features are shared across probable instruments, the more each probable instrument will be activated, as these shared features will boost activation of each of them. This explains why semantic similarity has an effect above and beyond semantic predictability; it is a semantic product of the processor trying to predict at every point what the most likely instrument is, semantically.

This chapter has tried to explain a clear difference in the range and kind of information that is relevant to the grammar of events and the online processing of sentences. Rather than rely on an implicit or explicit innateness hypothesis as to the kinds of semantic properties that are "visible" to grammar rules, we suggested that the explanation for the difference lies in task differences between grammar development and utterance processing. Given the charge of the grammar of events, focusing on properties that are type general and token independent is rational. So is focusing on the probability distribution in semantic space of fillers of argument positions of the sentence being read. While we cannot prove that both grammar development and utterance processing are sensitive to the same diverse sets of factors, we argue that there is no need to posit a restriction on which information is available to grammar development. Of course, the story we have told must be fleshed out and some further modeling is needed to show how under standard assumptions, learning mechanisms will zero in on a solution to the mapping problem that is both token independent (either verb-wise or construction-wise) and type general. But what is important for this chapter is that there is a plausible story to tell. There is a plausible cognitive explanation for why grammars are minimalist, and processing is promiscuous that avoids relying on unproven (and possibly unprovable) claims about cognitive architecture.

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Chapter 11
Verb Representation and Thinking-for-Speaking Effects in Spanish–English Bilinguals

Vicky T. Lai and Bhuvana Narasimhan

11.1 Introduction

Does the language we speak influence how we think about the events in our experience? If so, do bilingual speakers construe the same event in different ways, depending on the language they use to verbally encode that event? Or does one of the languages play a more dominant role in influencing event construal? The present study investigates whether bilingual speakers attend to different aspects of a motion event, depending on the language they use to first describe that event. Specifically, we explore whether language-specific verb representations used in encoding motion events influence subsequent performance in a nonlinguistic similarity judgment task in Spanish–English bilinguals.

We will begin by looking at different perspectives on whether language influences thought, including views on linguistic relativity and "thinking-for-speaking." Then we will focus on the domain of motion. We will present linguistic accounts of the semantic representations of motion verbs and discuss the crosslinguistic difference between English and Spanish. Next, we will review empirical studies that examine how verbal encodings influence motion event construal in monolinguals. We will also review empirical studies that explore linguistic relativity versus thinking-for-speaking in bilinguals. We then go on describe the current study. In the final section of the chapter, we discuss our findings in light of thinking-for-speaking effects, how events are conceptualized for language production, and the nature of representations in the bilingual mind.

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