

English Speakers Attend More Strongly Than Spanish Speakers to Manner of Motion When Classifying Novel Objects and Events

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Three experiments provide evidence that the conceptualization of moving objects and events is influenced by one's native language, consistent with linguistic relativity theory. Monolingual English speakers and bilingual Spanish/English speakers tested in an English-speaking context performed better than monolingual Spanish speakers and bilingual Spanish/English speakers tested in a Spanish-speaking context at sorting novel, animated objects and events into categories on the basis of manner of motion, an attribute that is prominently marked in English but not in Spanish. In contrast, English and Spanish speakers performed similarly at classifying on the basis of path, an attribute that is prominently marked in both languages. Similar results were obtained regardless of whether categories were labeled by novel words or numbered, suggesting that an English-speaking tendency to focus on manner of motion is a general phenomenon and not limited to word learning. Effects of age of acquisition of English were also observed on the performance of bilinguals, with early bilinguals performing similarly in the 2 language contexts and later bilinguals showing greater contextual variation.

Keywords: linguistic relativity, event, manner of motion, path, bilingualism

Whorf (1956) proposed that language influences nonlinguistic cognition, such that speakers of different languages have different conceptions of the world. The strongest interpretation of Whorf's

theory, which has been labeled *linguistic determinism*, is that people are unable to conceive of any notion that cannot be expressed in their language. Whorf's claims regarding the types of information that can and cannot be conveyed in different languages have since been contested (Pinker, 1994, 2007). A less extreme interpretation of Whorf's theory, however, remains a source of substantial controversy. This interpretation, which has been labeled *linguistic relativity*, suggests that certain concepts, although expressible in all languages, are more prominently marked in some languages than in others. As a result, these concepts are more readily formed and accessed by speakers of languages in which these concepts are prominently marked.

Although early studies designed to test the linguistic relativity theory proved largely negative (e.g., Heider & Oliver, 1972), a number of more recent lines of research have revealed influences of the structure and use of one's native language on more general cognitive performance. For example, Lucy and Gaskins (2001) found that speakers of Yucatec, a language in which nouns typically refer to objects of a particular substance rather than objects of a particular shape, were more likely to group objects on the basis of substance and less likely to group objects on the basis of shape than were speakers of English, a language that makes more frequent use of shape-based nouns. Furthermore, Levinson (1996) found that speakers of Tzeltal, a language in which directions are typically conveyed in terms of an absolute coordinate system (e.g., north, south), rather than the egocentric coordinate system (e.g.,

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left, right) typically used by English speakers, were more likely than English speakers to preserve the absolute relationships among the objects in a spatial layout when reproducing that layout in a different orientation. Moreover, Roberson, Davies, and Davidoff (2000) found that speakers of Berinmo, a language that fails to distinguish between green and blue, had greater difficulty than did English speakers at learning to sort green and blue color chips into separate piles, even when participants were given explicit feedback about which pile each chip belonged in. These and other results (e.g., Boroditsky, 2001; Boroditsky, Schmidt, & Phillips, 2003; Sera et al., 2002) suggest that language can influence one's perceptions and conceptions of experimental stimuli, causing one to attend to distinctions that are prominently marked in one's native language, even when overt linguistic responses are not required.

Motion Event Descriptions in English and Spanish

The present research was designed to test for influences of another prominent dimension of variation among languages on more general cognitive performance. In particular, it was designed to test if the way in which a motion event is typically described in one's native language influences one's conceptualization of motion events and the objects that participate in them. Motion events are typically described in English with sentences involving a verb in combination with a preposition or verb particle. The verb in such sentences typically conveys the manner of motion of the moving object in the event (Gentner & Boroditsky, 2001; Kersten, 1998a, 2003; Slobin, 2003; Talmy, 1985). Examples of such verbs are "running," "hopping," "slithering," and "scampering." Because such verbs convey no information about the global trajectory taken by an object as a result of carrying out these more detailed, repetitive motions, prepositions and verb particles (e.g., "in," "out," "up," "down") typically accompany these verbs to provide this path information. This same pattern can be seen in a number of languages from all over the world, including other Germanic languages, Slavic languages, and Mandarin Chinese.

Not all languages describe motion events in this way, however. In particular, verbs in many other languages, such as Spanish, typically convey the path of an object, and manner of motion is conveyed by an adverbial. For example, the English sentence "The rabbit hopped into the hole" would be expressed as "El conejo entró al hueco saltando," or "The rabbit entered the hole hopping," in Spanish. Although this is the literal translation of this English sentence, Spanish speakers typically fail to mention the manner of motion of an object unless they want to emphasize it (Naigles, Eisenberg, Kako, Highter, & McGraw, 1998). Thus, a Spanish speaker would typically describe this event simply as "El conejo entró al hueco." This same pattern can also be seen in many languages from all over the world, including other Romance languages, Semitic languages, Greek, Turkish, and Japanese.

This distinction between languages such as English and languages such as Spanish in the expression of motion events is of course relative rather than absolute. For example, English does have a number of verbs that convey the path rather than the manner of motion of an object (e.g., "enter," "exit," "ascend," "descend"); however, these verbs are typically used with much lower frequency than manner-of-motion verbs. Furthermore, Spanish does have a number of manner of motion verbs, such as "caminar" ("walk"), "correr" ("run"), and "saltar" ("jump," "bounce," or

"hop"). Such verbs can only be used when an event takes place entirely within a given region of space, however. Thus, if a Spanish speaker observed a rabbit hopping around in a field, he or she could describe this event as "El conejo saltó." This verb would no longer apply, however, if the rabbit left this geographical area and moved into a different one (e.g., its hole), because Spanish manner-of-motion verbs cannot be combined with path prepositions to describe where this manner of motion carries the subject of the sentence (Slobin, 2004). Thus, although English does have path verbs and Spanish does have manner-of-motion verbs, path verbs are used with higher frequency in Spanish than in English, and manner-of-motion verbs are used with higher frequency and in a greater variety of syntactic contexts in English than in Spanish.

Because English motion event descriptions involve frequent use of both manner-of-motion verbs and path prepositions, whereas Spanish motion event descriptions involve frequent use of path verbs in the absence of any explicit specification of manner of motion, the key difference between these two patterns would appear to be that manner of motion is given greater prominence in English than in Spanish (see Slobin, 2004, 2006, for more general discussions of the relative salience given to path and manner of motion in a variety of different languages). Linguistic relativity theory thus predicts that speakers of English, as a result of habitually attending to the manner of motion of an object in an event to produce the correct verb, may come to attend to manner of motion information more generally, even in a task that does not require overt language production. The present experiments test this prediction.

Previous Studies Examining Attention to Manner of Motion

Despite these differences in the way motion events are described in different languages, a number of recent studies have failed to reveal differences in the way speakers of these different languages conceptualize events when linguistic responses are not required. These results thus provide no support for the linguistic relativity theory within the domain of motion events. In one such study, Papafragou, Massey, and Gleitman (2002) presented a recognition memory test and a similarity judgment task to English speakers and speakers of Greek, a language that follows the Spanish pattern of using the verb to convey path and leaving manner to an optional adverb. Neither task revealed any differences between English speakers and Greek speakers in their attention to manner of motion, suggesting that the differential prominence of manner of motion in the two languages had no effect on performance in a task that did not require overt linguistic responses.

One potential limitation of this study, however, is that no actual motions were displayed. Instead, participants viewed static pictures representing motion events and had to infer path and manner of motion on the basis of these static depictions. English speakers must in fact have been able to discern the manner of motion represented in these pictures, judging by the fact that, when asked to describe the pictures, English speakers were more likely than Greek speakers to use manner of motion verbs (see also Papafragou, Massey, & Gleitman, 2006). Unlike the conscious, controlled process of describing a picture, however, directing one's attention to different attributes of a stimulus may be a much more automatic, stimulus-driven process. Thus, if English speakers have indeed

developed a tendency to focus on manner of motion as a result of English verb-learning experience, this tendency may reflect the operation of relatively low-level attentional mechanisms that are sensitive to the detailed patterns of motion present in a stimulus (e.g., the repetitive, cyclical movements of body parts). Given that such motions were not in fact present in the stimuli of Papafragou et al. (2002), it remains possible that English speakers may still reveal a tendency to attend to manner of motion, but only in the context of more dynamic stimuli.

A more recent study by Papafragou, Hulbert, and Trueswell (2008) appears to circumvent this limitation of Papafragou et al. (2002), examining English and Greek speakers' attention to path and manner information in the context of a recognition memory task for dynamic events. Eye-movement data from these participants revealed different patterns of attention in the two language groups when participants were instructed to describe the events. In contrast, the two groups exhibited quite similar patterns of attention to the manner and path in an ongoing event when no such instruction was given. These results again suggest that cross-linguistic differences in the way events are described have no effect on the way those events are encoded in the absence of a requirement for linguistic responses.

Although the study by Papafragou et al. (2008) involved dynamic events, the cues that allowed one to infer the manner of motion in an event remained essentially static. In particular, the events involved clip-art images, such as a picture of a skater, translating across a computer screen. Because participants were not presented with the arm and leg motions skaters typically perform to achieve this translatory motion, the only cues to indicate the manner of motion of the skater were his posture and the presence of the skates themselves. The authors chose to represent manner of motion in this way to facilitate interpretation of the eye-movement data from their participants. Because of the decision not to present the relative motions of the parts of the actor, however, the only motion that was present in the displays involved the translatory motion of the actor as a whole (i.e., a path). Thus, if an English-speaking tendency to focus on manner of motion stems from the operation of low-level attention mechanisms that are sensitive to particular patterns of motion that indicate an actor's manner of motion, the stimuli used by Papafragou et al. (2008) may not reveal this sensitivity.

In a third study that did involve truly dynamic stimuli, Gennari, Sloman, Malt, and Fitch (2002) presented native English and Spanish speakers with a similarity judgment task, in which participants viewed a target event involving an actor moving along a particular path with a particular manner of motion (e.g., walking up the stairs). Participants were then presented with two further events and were asked which of these two events was more similar to the target event. One of these events, the same-manner alternate, involved the same actor moving with the same manner of motion along a different path (e.g., walking down the stairs). The second event, the same-path alternate, involved the same actor moving along the same path as in the target event, but with a different manner of motion (e.g., jumping up the stairs). Linguistic relativity theory would appear to predict that English speakers should be more likely than Spanish speakers to choose the same-manner alternate, because English speakers should be more likely than Spanish speakers to attend to manner of motion when viewing the target event. This effect was only observed, however, when par-

ticipants were instructed to describe the target event with a verb phrase before making the similarity judgment. This result suggests that English speakers were more likely than Spanish speakers to attend to manner of motion because attention to manner of motion was necessary to choose the most appropriate English verb. In contrast, under free encoding conditions, Spanish speakers were just as likely as English speakers to choose the same-manner alternate. Similar results were observed in a recognition memory test for the events.

The results of Gennari et al. (2002) would appear to be inconsistent with the prediction of linguistic relativity that English speakers should be more likely than Spanish speakers to attend to manner of motion in a task that does not require overt linguistic responses. One feature of the design of Gennari et al.'s study that may have worked against finding this effect, however, is that participants had to choose between path and manner of motion as to which was more important to event similarity. Although one might expect English speakers to be more likely to focus on manner of motion than on path because manner of motion is more frequently encoded in English verbs, path is also prominently marked in English in the form of verb particles and prepositions. In fact, Kersten (1998a) found that adult English speakers focused more strongly on path than on manner of motion in a novel verb-learning task, suggesting that path was a more salient attribute of an event than was manner of motion for these participants. Thus, it is possible that English speakers in the study of Gennari et al. also found path to be the more salient attribute, resulting in reduced attention to manner of motion in these participants. Consistent with this suggestion, English speakers chose the same-path alternate about 65% of the time (and thus chose the same-manner alternate only 35% of the time) under free encoding conditions in Gennari et al.'s similarity task. Thus, English speakers showed relatively little attention to manner of motion in this task, making it difficult to show even less attention to manner of motion in Spanish speakers.

The present experiments employed different stimuli and a different task from those used in these prior studies, in order to increase the likelihood of detecting any English-speaking tendency to focus on manner of motion. First, unlike the static representations of manner of motion employed by Papafragou et al. (2002) and Papafragou et al. (2008), the manners of motion in the present experiments were dynamic, involving the relative motions of the parts of novel, bug-like creatures as they moved around on a computer screen. Thus, if an English-speaking tendency to focus on manner of motion reflects the operation of relatively low-level attentional mechanisms sensitive to particular patterns of motion, the present stimuli should be more likely to recruit such mechanisms than were the stimuli used in these earlier studies.

Second, unlike in Gennari et al.'s (2002) similarity task, participants were not given the opportunity to choose whether to categorize stimuli on the basis of manner or path. Instead, one of these bases for categorization was imposed upon them, and they had to discover what it was. In particular, participants were given a supervised classification task, similar in structure to supervised classification tasks that have been used to study effects of language on color perception (e.g., Roberson, Davidoff, Davies, & Shapiro, 2005; Roberson et al., 2000). In the present task, participants were asked to classify moving objects and events into four novel categories. After participants classified each stimulus, they were given

feedback about the correct category assignment for that stimulus. For half of the participants, the correct category assignment was determined by the manner of motion of the moving creature in an event, whereas for the other half of the participants, the correct category assignment was determined by the path of the moving creature with respect to another creature. Thus, participants in the manner of motion condition who initially looked to path to try to discriminate the categories would have quickly discovered that path was not relevant. Under these conditions, with path ruled out as a basis for classification but with a number of alternative bases remaining, English speakers may reveal a tendency to focus on manner of motion because of their language learning history in which this attribute was prominent.

Experiment 1

Experiment 1 was designed to examine attention to novel manners of motion by native English speakers and native Spanish speakers in a category-learning task. We presented participants with a number of animated events, each involving two novel, bug-like creatures (see Figure 1). After each event, four buttons appeared on the screen, representing the four different categories to be discriminated. Participants clicked on one of the four buttons to indicate in which category they believed the event belonged, after which they were given feedback regarding the correct category assignment. In the critical conditions of the experiment, the only attribute that distinguished the four categories was the manner of motion of one of the creatures in each event. In particular, the creature moved its legs in one of four different ways with respect to its body (see Figure 2), and the four categories corresponded to these four different manners of motion.

The four categories to be learned were given novel linguistic labels in Experiment 1. In particular, for half of the participants who were tested on the manner of motion discrimination, the four categories were labeled by four different novel verbs. Thus, if English speakers in this condition exhibited better performance than Spanish speakers at learning to discriminate the categories in terms of manner of motion, this could reflect a verb-learning strategy on the part of English speakers. In particular, English speakers may have learned to focus on manner of motion in a verb-learning context as a result of learning a large number of manner of motion verbs (see, e.g., Naigles & Terrazas, 1998).

For the other half of the participants who were tested on the manner of motion discrimination in Experiment 1, the four categories were labeled by four different novel nouns. This condition was included to provide an initial demonstration of generality in a tendency of English speakers to focus on manner of motion. In particular, if English speakers performed better than Spanish speakers on a manner of motion discrimination not only when categories were labeled by verbs but also when categories were labeled by nouns, this would suggest that a tendency to focus on manner of motion had generalized from a verb-learning context, in which this tendency was presumably acquired, to a noun-learning context. This evidence of generalization would open the door to the possibility that attention to manner of motion in English speakers is a more general phenomenon, the generality of which is explored in Experiments 2 and 3.

In addition to testing participants on a manner of motion discrimination task, a separate group of participants was tested on a

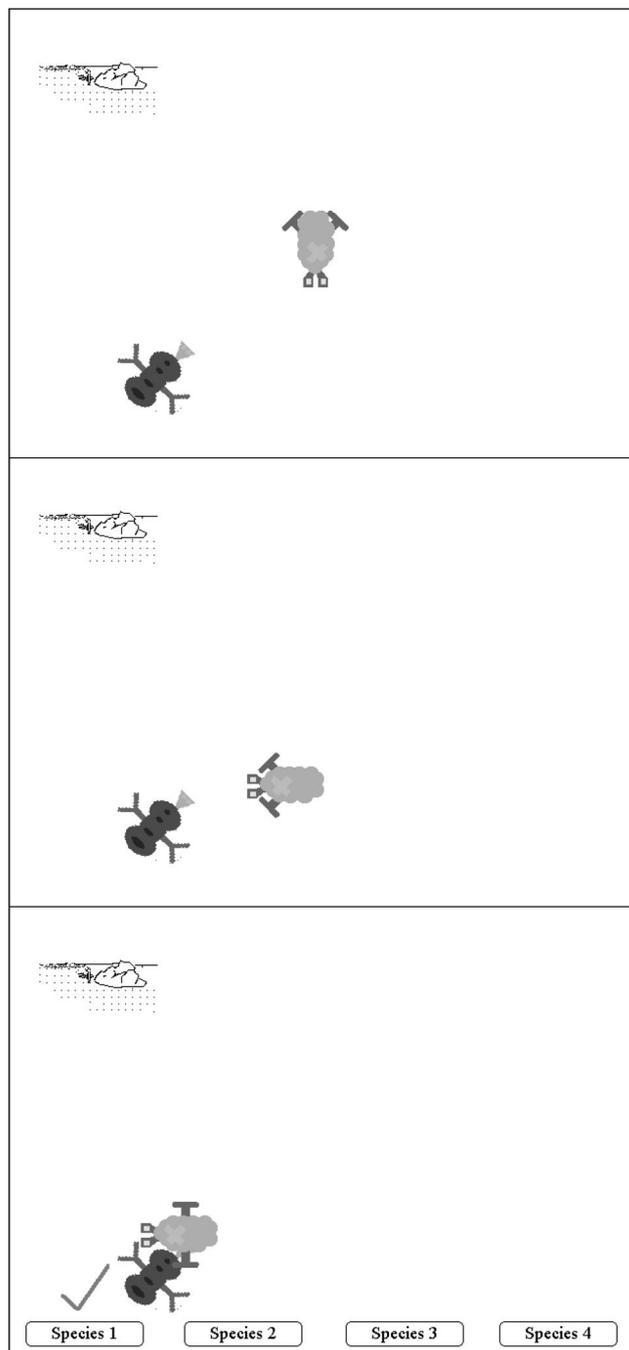


Figure 1. Three frames from an example event. Animated examples of the events used as stimuli in this research are available online at http://psy.fau.edu/~kersten/Movies/Kersten_et_al_Movie.mov

path discrimination task (see Table 1 for a schematic representation of the different conditions of the experiment). In particular, for these participants, the four categories to be learned could be distinguished only on the basis of the path of the moving creature with respect to the stationary creature in the event. The reason for including this condition was that the manner of motion of an animate creature is typically (although not always) accompanied

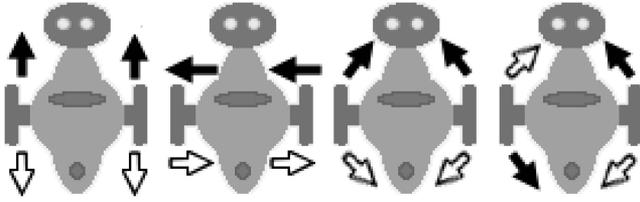


Figure 2. The four different manners of motion that were displayed in the experiment. A creature started each event in its depicted configuration. A creature first moved its legs in the directions represented by the dark arrows. A creature then returned to its original configuration, after which it moved its legs in the directions represented by the clear arrows. A creature then returned again to its original configuration, starting the process over again. Diagonal arrows indicate a rotating motion around the body of the creature. For example, in the manner of motion depicted on the far right, the left leg of the creature initially rotated backward while the right leg rotated forward. The creature then returned to its initial state, after which the left leg rotated forward and the right leg rotated backward before returning to the initial state again.

by movement of the creature as a whole, and thus a manner of motion typically causes a creature to move along a path. Path information may thus compete with manner of motion information for a participant's attention, leading to the possibility that group differences in attention to manner of motion may in fact stem from group differences in attention to path.

To test for this possibility, half of the participants in each language group were presented with a category-discrimination task in which the four categories to be discriminated mapped onto four different paths of the moving creature. In particular, the moving creature in an event sometimes moved directly toward the stationary creature, with the event ending when the two came into contact. In other events, a creature took an indirect path toward the stationary creature, moving at a 45° angle with respect to the stationary creature and then making a single 90° turn halfway through the event, ultimately resulting in the two creatures coming into contact (see Figure 1). The third and fourth paths involved movement away from the stationary creature, with one path involving movement directly away from the stationary creature and one involving a single 90° turn. Thus, in English, these four paths could be described as “directly toward,” “indirectly toward,” “directly away,” and “indirectly away,” respectively, whereas in Spanish, they could be described as “acercarse directamente,” “acercarse indirectamente,” “alejarse directamente,” and “alejarse indirectamente.”

Because these four paths could be straightforwardly described by existing words in either Spanish or English, and because path information in general is prominently marked both in Spanish (by verbs) and in English (by verb particles and prepositions), we predicted that English and Spanish speakers would be equally likely to attend to these paths when attempting to discriminate the four categories. Thus, when paths indeed discriminated the four categories, we expected the two groups to perform equally well. This finding would also suggest that participants who were assigned the manner-discrimination task would be equally likely to first attempt to map the four categories onto paths before ultimately discovering the manner of motion, thus arguing against the hypothesis that group differences in attention to manner of motion derived from group differences in attention to paths.

If Spanish speakers perform as well as monolingual English speakers on the path-discrimination task, this would allow one to rule out a second alternative hypothesis for any group differences in the manner discrimination task. In particular, if English speakers performed better than Spanish speakers on the manner-discrimination task, one could potentially argue that this difference was not a result of the different language learning experiences of the two groups but, rather, reflected general performance differences between the two samples (e.g., motivation, intelligence). Although the different groups of participants came from similar university populations, random assignment of participants to language groups was obviously not possible, and thus, there may have been other differences between English and Spanish speakers. If a disadvantage to the Spanish speakers in the manner-discrimination task were a result of differences other than language background, however, one would expect the Spanish speakers to be similarly disadvantaged in the path-discrimination task. If Spanish speakers performed just as well as English speakers on the path-discrimination task, this would suggest that the groups were well-matched in terms of general performance variables, ruling out such variables as an explanation for any differences in the manner-discrimination task.

Method

Participants. One hundred twenty native English speakers and 120 native Spanish speakers received course credit in general psychology classes for participation. The English speakers and 30 of the Spanish speakers were students at Florida Atlantic University (FAU), whereas the remaining 90 Spanish speakers were students at Florida International University (FIU). These two universities are quite similar in terms of the demographics of the students, with the exception that a much higher percentage of students at FIU are native Spanish speakers. Spanish speakers at both universities are typically of Cuban, Dominican, Central American, or South American descent. Participants were selected by posting signup sheets labeled “Native English speakers only” and “Native Spanish speakers only.” A bilingual Spanish/English-speaking experimenter conversed with participants in their native language to ensure that they were indeed speakers of the appropriate language. All Spanish-speaking participants were in fact bilingual, given that they had to be proficient in English to enroll in classes. The average age at which Spanish-speaking participants were first exposed to English was 6.6 ($SD = 4.2$) years. The average number of years that Spanish-speaking participants had been speaking English was 13.7 ($SD = 4.8$) years.

Stimuli. Participants viewed a number of animated events, each involving two novel, bug-like creatures (see Figure 1). Animations were created using the Macromedia Director software package (Version 6.5, Macromedia, Inc.) and were displayed on

Table 1
Schema for Experiment 1

Diagnostic attribute	Category label	<i>n</i> English	<i>n</i> Spanish
Path	Verbs	60	60
Manner of motion	Verbs	30	30
	Nouns	30	30

17-in. (43.18-cm) computer monitors. In each event, one of the creatures moved on one of four different paths with respect to the other creature, which was stationary. In addition, the moving creature moved its legs in one of four different manners of motion in each event (see Figure 2). Events also varied randomly along a number of other attributes, namely the appearance of the head, body, and legs of the moving creature, the appearance of the head, body, and legs of the stationary creature, and the background scene against which the event took place. Each of these attributes had four possible values, selected at random in each event. The absolute locations of the creatures on the screen also varied randomly from event to event.

After each event, participants had to decide in which of four categories the event belonged. Four different buttons appeared on the screen, each with a different category label. Participants clicked on one of the four buttons with a computer mouse to indicate their choice, after which feedback was given. A check appeared above the button a participant had chosen if he or she was correct, or an X appeared above the button the participant should have chosen if he or she was incorrect. Thus, although participants at first could only guess the category to which an event belonged, with feedback a participant could start to learn the appropriate category for each event.

The four categories to be learned were labeled by four different verbs for all of the participants who were presented with the path category discrimination and for half of the participants who were presented with the manner-of-motion category discrimination. Novel verbs were chosen that had the phonological properties of the native language of the participant but did not closely resemble any particular word in that language. Novel verbs for English speakers were “morping,” “spogging,” “wunking,” and “yim-ming.” Novel verbs for Spanish speakers were “gorapar,” “le-geser,” “mapader,” and “taruchar.” The assignment of verbs to values of path and manner of motion was chosen randomly for each participant.

The four categories to be learned were labeled by four different nouns for the other half of the participants who were presented with the manner of motion category discrimination. Novel nouns for English speakers were “a doovil,” “a racha,” “a taygo,” and “a zeebee.” Novel nouns for Spanish speakers were “una ceba,” “una dova,” “un racho,” and “un taigo.” The assignment of nouns to values of manner of motion was chosen randomly for each participant.

Procedure. All orally presented as well as visually presented instructions to monolingual English speakers were given in English, whereas all instructions to bilingual Spanish/English speakers were given in Spanish. The instructions were translated from English to Spanish by a fluent bilingual Spanish/English speaker. After reading the instructions, participants were presented with five blocks of learning trials. Each learning block consisted of 16 trials. The events depicted in these trials comprised the 16 possible combinations of the values of manner of motion and path. The order of presentation of these 16 events was chosen randomly for each block for each participant. The correct category assignment for an event was determined by the path depicted in that event for participants who were assigned the path-discrimination task, whereas it was determined by the manner of motion for participants who were assigned the manner-discrimination task. Because path and manner of motion varied orthogonally, when path was

predictive of category membership, manner of motion was unrelated. Similarly, when manner of motion was predictive, path was unrelated. After each block of trials, participants were given a rest break and were shown their percentage correct on that block.

Design. The dependent variable in this experiment was the percentage of correct choices in the category-discrimination task. The independent variables for this analysis were language group (English vs. Spanish), varying between subjects; relevant type of motion (manner vs. path), manipulated between subjects; and learning block (1–5), manipulated within subjects. A secondary analysis focused specifically on the percentage of correct choices in the manner category-discrimination task, with language group, learning block, and category label type (noun vs. verb) as independent variables.

Results

An alpha level of .05 was adopted for all analyses. The results of the manner-discrimination task are depicted in Figure 3, and the results of the path-discrimination task are depicted in Figure 4. An analysis of variance (ANOVA) on the percentage of correct

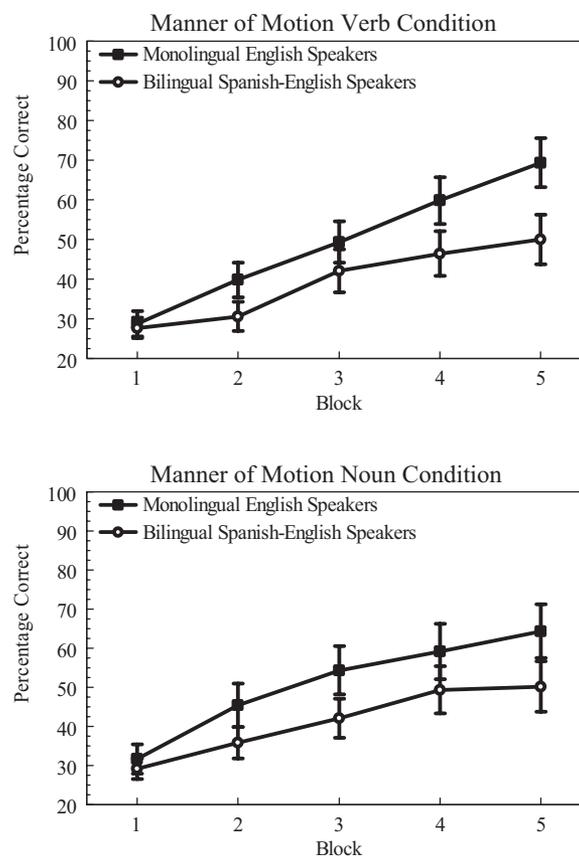


Figure 3. Results of the manner-of-motion category-discrimination task in Experiment 1. The upper panel depicts performance when the four categories were labeled by four different novel verbs, whereas the lower panel depicts performance when the four categories were labeled by four different novel nouns. Error bars represent standard errors. Twenty-five percent reflects chance performance.

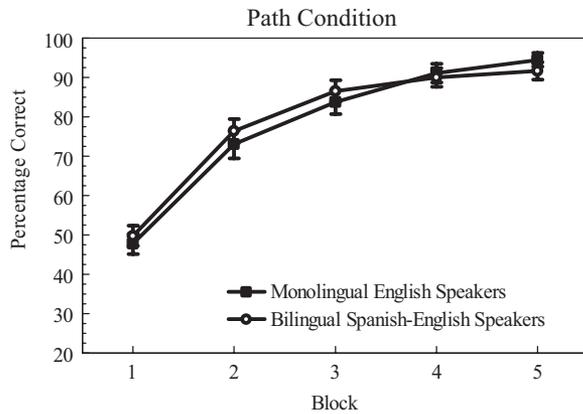


Figure 4. Results of the path category-discrimination task in Experiment 1. Error bars represent standard errors. Twenty-five percent reflects chance performance.

choices in these category-discrimination tasks, with language group, motion type, and learning block as independent variables, revealed a significant main effect of learning block, $F(4, 944) = 225.36$, $p < .001$, $MSE = 231.33$, indicating that performance improved across the five blocks of trials. There was also a significant main effect of motion type, $F(1, 236) = 149.88$, $p < .001$, $MSE = 2201.82$, as well as a significant interaction of motion type and learning block, $F(4, 944) = 15.73$, $p < .001$, $MSE = 231.33$, indicating better overall performance and faster improvement over learning blocks in the path-discrimination task than in the manner-discrimination task. Finally, there were two significant interactions involving language group, namely an interaction of language group and learning block, $F(4, 944) = 3.65$, $p < .01$, $MSE = 231.33$, and an interaction of motion type and language group, $F(1, 236) = 3.91$, $p < .05$, $MSE = 2201.82$.

To understand the interaction of motion type and language group, the effects of language group were analyzed separately for the two types of motion. This analysis revealed that English speakers performed significantly better than Spanish speakers on the manner-discrimination task, $t(118) = 2.20$, $p < .05$, consistent with the hypothesis that category learners attend to attributes that are prominently marked in their native language. In contrast, there was not a significant difference between the two language groups on the path-discrimination task, $t(58) = 0.60$, $p > .10$, indicating that Spanish speakers performed just as well as English speakers at learning to discriminate categories on the basis of a type of motion that is prominently marked in both languages.

An additional analysis examined if the type of word used to label the categories influenced learning in the manner discrimination task. In particular, an ANOVA was conducted on performance in the manner-discrimination task, with language group, learning block, and word type (verb vs. noun) as independent variables. No significant effects involving word type were revealed (all $F_s < 1$). In particular, as can be seen in Figure 3, the learning of manner-of-motion categories labeled by nouns closely paralleled the learning of categories labeled by verbs, with faster learning in English speakers than in Spanish speakers. These results thus indicate that an English-speaking advantage in learning novel manner-of-motion categories is not limited to a verb-learning context but, rather, is a more general phenomenon.

Discussion

The results of Experiment 1 are consistent with the prediction that English speakers attend more strongly to the manner of motion of an object than do Spanish speakers. In particular, English speakers performed better than Spanish speakers on a manner of motion category-discrimination task, indicating that English speakers were faster to notice that manner of motion could be used to discriminate the four categories. English speakers and Spanish speakers performed equivalently on a path category-discrimination task, allowing one to rule out the hypothesis that the English-speaking advantage on the manner-discrimination task resulted from general performance differences between the two language groups.

The results of Experiment 1 also provide evidence of generality in an English-speaking tendency to focus on manner of motion, demonstrating that English speakers attend more strongly to manner of motion than do Spanish speakers not only in a verb-learning context but also in a noun-learning context. Thus, although a tendency to focus on manner of motion was presumably acquired in the context of verb learning, there is evidence of generalization of this tendency to at least one other context. This evidence of generalization raises the possibility that influences of one's native language on attention to manner of motion may extend further, perhaps even outside of a word-learning context. Such influences would provide support for the linguistic relativity theory.

Experiment 2

Experiment 2 was designed to test more directly the prediction that native English speakers attend more strongly to manner of motion than do native Spanish speakers, even outside of a word-learning context. To this end, the task that was employed in Experiment 1 was altered such that no novel nouns or verbs were presented as category labels. Instead, participants were told that life had been discovered on the planet Mars and that scientists had identified four distinct species of creatures on the basis of their genetic signatures. Participants were told that these four species all looked pretty much the same, however, and that their task as young biologists was to try to distinguish the four species on the basis of their observable characteristics. They were then presented with essentially the same category-learning task that was employed in Experiment 1, except that the four species to be learned were simply numbered one through four. Path discriminated the four species for half of the participants, whereas manner of motion discriminated the four species for the other half. Participants were thus asked to perform a category-discrimination task in the absence of novel linguistic labels. Any differences in performance between English and Spanish speakers in the manner-discrimination task would provide evidence for an influence of native language on nonlinguistic cognition, consistent with the linguistic relativity theory.

Experiment 2 also differed from Experiment 1 in that monolingual English speakers were compared with monolingual Spanish speakers, rather than with bilingual Spanish/English speakers. The interpretation of Experiment 1 is complicated by the fact that all of the Spanish speakers tested in that experiment were also fluent speakers of English, perhaps attenuating any differences in performance between those Spanish speakers and the monolingual En-

lish speakers to which they were being compared. The Spanish speakers in Experiment 2, on the other hand, attended a Spanish-speaking university in Mexico and had spent an average of 3 months living in the United States. Spanish was also the dominant language spoken in the homes of all of the Spanish-speaking participants as they were growing up, and thus, none of the Spanish-speaking participants in Experiment 2 were fluent in English.

Method

Participants. Sixty monolingual English speakers received course credit in general psychology classes at FAU for their participation. Sixty monolingual Mexican Spanish speakers enrolled in psychology classes at the Universidad Autónoma de Ciudad Juárez participated on a voluntary basis.

Stimuli and procedure. The stimuli and procedure were identical to those of Experiment 1 with the following exceptions. First, no novel linguistic labels appeared on the four categories. Instead, the four categories were represented by four buttons on the computer screen, labeled “Species 1,” “Species 2,” “Species 3,” and “Species 4” for English speakers, and “Especie 1,” “Especie 2,” “Especie 3,” and “Especie 4” for Spanish speakers. Second, participants completed six blocks of trials rather than five to provide a more stable measure of each participant’s performance.

Design. The dependent variable in this experiment was the percentage of correct choices in the category-discrimination task. The independent variables for this analysis were language group (monolingual English speakers vs. monolingual Spanish speakers), varying between subjects; relevant type of motion (manner vs. path), manipulated between subjects; and learning block (1–6), manipulated within subjects.

Results

The results of Experiment 2 are depicted in Figure 5. An ANOVA on the percentage of correct choices in the category-discrimination task, with language group, motion type, and learning block as independent variables, revealed a significant main effect of learning block, $F(5, 580) = 59.93, p < .001, MSE = 309.76$, indicating that performance improved over the six blocks of trials. There was also a main effect of language group, $F(1, 116) = 6.22, p < .01, MSE = 3718.05$, with better performance in English speakers than in Spanish speakers. This main effect, however, was moderated by a significant interaction of language group and learning block, $F(5, 580) = 3.34, p < .01, MSE = 309.76$, and, more important, a significant interaction of language group and motion type, $F(1, 116) = 7.84, p < .01, MSE = 3718.05$.

To understand the interaction of language group and motion type, the effects of language group were analyzed separately for the two motion types. This analysis revealed that English speakers performed significantly better than Spanish speakers on the manner-discrimination task, $t(58) = 4.08, p < .001$. These results with monolingual Spanish speakers thus replicate the results with bilingual Spanish/English speakers in Experiment 1. In contrast, there was not a significant difference between English and Spanish speakers on the path-discrimination task, $t(58) = 0.20, p > .10$, indicating that the two groups of participants were well matched in terms of general performance variables.

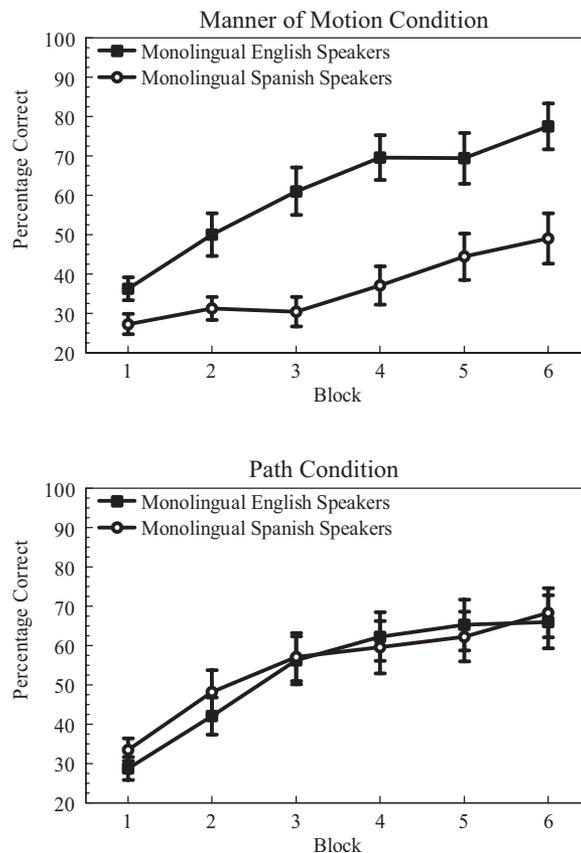


Figure 5. Results of the manner-of-motion and path category-discrimination tasks in Experiment 2. Error bars represent standard errors. Twenty-five percent reflects chance performance.

The interaction of language group and motion type was also examined by analyzing the effects of motion type separately for the two language groups. This analysis revealed that Spanish speakers performed significantly better on the path-discrimination task than on the manner-discrimination task, $t(58) = 2.96, p < .01$. In contrast, English speakers did not perform significantly differently in the two tasks (with the ordinal advantage in the direction of the manner-discrimination task), $t(58) = 1.08, p > .10$, indicating that the two discrimination tasks were approximately equal in difficulty to English speakers.

Discussion

The results of Experiment 2 revealed that monolingual English speakers were more likely than monolingual Spanish speakers to notice the relevance of manner of motion in a category-discrimination task. This result suggests that English speakers have learned to attend to manner of motion as a result of English language learning experience in which that attribute is relevant, and that this tendency transfers to a task in which overt language production is not required. In contrast to performance on the manner-discrimination task, Spanish speakers performed just as well as English speakers on a path-discrimination task. This result suggests that the two groups were well matched in performance

when tested for attention to an attribute that is prominently marked in both languages.

The results of Experiment 2 argue against the hypothesis that an English-speaking advantage in the manner-discrimination task stems from general performance differences between the two groups. This hypothesis could still be considered viable on the basis of the results of Experiment 1, given that performance on the path-discrimination task was generally much better than performance on the manner-discrimination task in that experiment. Thus, it was possible that the lack of a significant difference between the two language groups on the path-discrimination task in Experiment 1 was a result of a ceiling effect. Performance on the manner- and path-discrimination tasks was much more evenly matched in Experiment 2, however. In fact, English speakers exhibited ordinarily (but not significantly) better performance on the manner-discrimination task than on the path-discrimination task, in contrast to Experiment 1. Spanish speakers, on the other hand, performed significantly better on the path-discrimination task than on the manner-discrimination task, consistent with the relative prominence given to these two attributes in Spanish.

The greater difficulty of the path-discrimination task in Experiment 2 than in Experiment 1 most likely reflects the fact that both the manner- and path-discrimination tasks were framed as object category learning tasks in Experiment 2, whereas the path discrimination was framed as a verb-learning task in Experiment 1. Previous research by Kersten (1998a, 1998b; Kersten & Billman, 1997) has revealed that the learning of verbs promotes attention to paths to a greater extent than does the learning of nouns or unlabeled object categories, which instead tends to promote attention to manner of motion. Because framing the path-discrimination task as an object category learning task in Experiment 2 brought performance well below ceiling, and yet no language group differences were evident on this task, one can rule out the hypothesis that a Spanish language background generally leads to poorer performance. A Spanish-speaking disadvantage instead appears to be limited to the manner-discrimination task.

Experiment 3

Experiments 1 and 2 revealed similar patterns of performance in monolingual Spanish speakers and bilingual Spanish/English speakers, with both groups performing more poorly than monolingual English speakers on a manner-discrimination task. It remains possible, however, that the performance of bilinguals may diverge from that of monolingual Spanish speakers in certain contexts. Perhaps most notable, both monolingual Spanish speakers and bilingual Spanish/English speakers were tested in a Spanish language context in Experiments 1 and 2, with all interactions between the experimenter and the participants taking place in Spanish, the consent form written in Spanish, and all on-screen instructions given in Spanish. To the extent that a Spanish language context promotes a Spanish “mode of thought” in bilinguals (e.g., Grosjean, 2001), it is possible that testing bilinguals in an English language context may yield performance more similar to that of monolingual English speakers (and thus quite different from that of monolingual Spanish speakers and bilingual Spanish/English speakers tested in a Spanish language context).

Alternatively, it is possible that the two languages of a fluent bilingual jointly influence his or her thinking, regardless of the

immediate linguistic context in which he or she is immersed. Thus, regardless of whether tested in an English or a Spanish language context, the performance of Spanish/English bilinguals may be intermediate between that of Spanish and English monolinguals, paying greater attention to manner of motion than do Spanish monolinguals (because of English language experience in which manner of motion is prominent), but paying less attention to manner of motion than do English monolinguals (because of Spanish language experience in which manner of motion is less prominent).

A further possibility is that the performance of bilinguals may vary depending upon the circumstances of bilingualism. For example, there is evidence that a common neural substrate underlies competence in the bilingual’s two languages when those languages were both learned early in life (e.g., Weber-Fox & Neville, 1999). Thus, the two languages of an early bilingual may share a common representational system, leading to similar performance regardless of the immediate linguistic context. In contrast, bilinguals who were exposed to their second language later in life draw upon somewhat separable neural substrates when processing the two languages, suggesting at least partially independent representational systems and thus possibly different performance depending upon linguistic context.

To address these possibilities, the performance of Spanish/English bilinguals who were exposed to English at varying ages was examined both in a Spanish and in an English linguistic context, to determine the extent to which the performance of these different groups of bilinguals resembled the performance of monolingual English speakers and monolingual Spanish speakers. In particular, half of the bilingual participants were tested in English, conversing with the experimenter in English and receiving the same instructions as were given the English speakers. The other half were tested in Spanish, as in Experiment 1. Any difference in performance between these two groups would provide evidence for distinct patterns of attending in bilinguals associated with the two languages that they speak.

Method

Participants. Sixty native English speakers and 240 native Spanish speakers received course credit in general psychology classes for participation. The English speakers were students at FAU. Half of the Spanish speakers were students at FIU, whereas half were students at the University of Texas at El Paso (UTEP). Although these two universities are similar in that they both enroll large Spanish-speaking populations, these populations derive from different regions of the Spanish-speaking world. In particular, as stated previously, most Spanish speakers at FIU are of Cuban, Dominican, Central American, or South American descent. In contrast, most Spanish speakers at UTEP are of Mexican descent. A comparison of Spanish speakers at these two universities thus provides some indication of the generality of any effects of a Spanish language background. As in Experiment 1, all Spanish-speaking participants were bilingual. The average age at which Spanish-speaking participants were first exposed to English was 6.2 ($SD = 4.6$) years. The average number of years that Spanish-speaking participants had been speaking English was 13.4 ($SD = 5.3$) years. Bilinguals at FIU and UTEP did not differ in either their

average age of first exposure or their average number of years speaking English (both $t_s < 1$).

Stimuli and procedure. The stimuli and procedure were identical to those of Experiment 2 with the following exceptions. First, bilingual participants were randomly assigned to one of two different groups. For half of the bilingual participants, all of the interactions with the experimenter were in English, the consent form was written in English, and all of the instructions on the computer screen were in English. For the other half of the bilingual participants, all of the interactions with the experimenter, the consent form, and the computerized instructions were in Spanish, as in Experiment 1. The four categories to be learned were represented by four buttons on the computer screen labeled “Species 1,” “Species 2,” “Species 3,” and “Species 4” for English speakers and for bilinguals tested in English. These same buttons were labeled “Especie 1,” “Especie 2,” “Especie 3,” and “Especie 4” (the Spanish translation of the singular form of the English term “species”) for UTEP bilinguals tested in Spanish and by “Especies 1,” “Especies 2,” “Especies 3,” and “Especies 4” (the Spanish translation of the plural form of the English term “species”) for FIU bilinguals tested in Spanish.

Design. The dependent variable in this experiment was the percentage of correct choices in the category-discrimination task. The independent variables for this analysis were language group (monolingual English speakers vs. FIU bilinguals tested in English vs. FIU bilinguals tested in Spanish vs. UTEP bilinguals tested in English vs. UTEP bilinguals tested in Spanish), varying between subjects; relevant type of motion (manner vs. path), manipulated between subjects; and learning block (1–6), manipulated within subjects.

Results

Effects of bilingualism and language context. The results of Experiment 3 are depicted in Figure 6. An ANOVA on the percentage of correct choices in the category-discrimination task, with language group, motion type, and learning block as independent variables, revealed a significant main effect of learning block, $F(5, 1450) = 161.92, p < .001, MSE = 328.35$, indicating that performance improved over the six blocks of trials. There was also a significant interaction of learning block and motion type, $F(5, 1450) = 2.93, p < .01, MSE = 328.35$, indicating faster improvement over learning blocks in the path-discrimination task than in the manner-discrimination task.

The effects of language group in this experiment were analyzed using four orthogonal planned comparisons (see Table 2). The first comparison examined the effects of a Spanish versus an English linguistic context on attention to manner of motion and path. In particular, the performance of monolingual English speakers and bilinguals tested in English was compared with the performance of bilinguals tested in Spanish. The second comparison examined the effects of bilingualism in the absence of differences in linguistic context, contrasting the performance of monolingual English speakers with the performance of bilinguals tested in English. Finally, the third and fourth comparisons tested for differences in the performance of the two bilingual populations (i.e., FIU vs. UTEP), with the third comparison contrasting the performance of FIU bilinguals tested in English and UTEP bilinguals tested in English and the fourth comparison contrasting the performance of

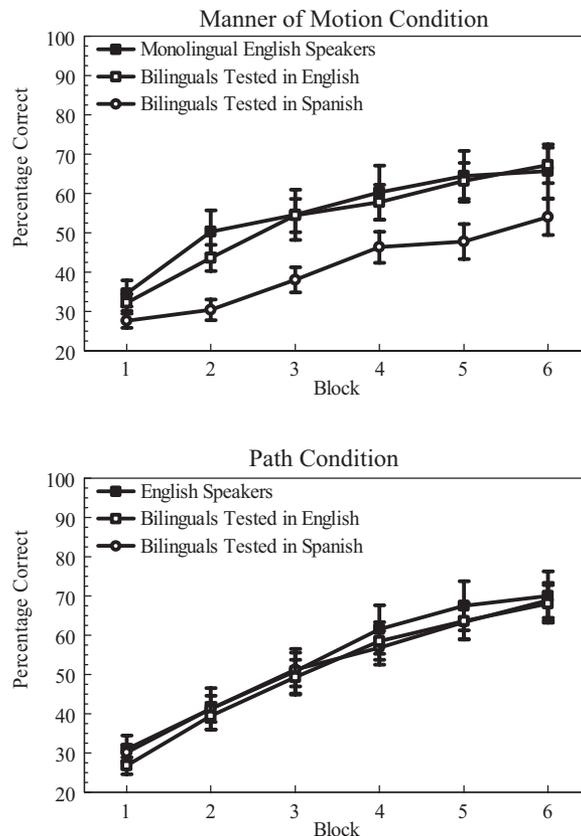


Figure 6. Overall results of the manner-of-motion and path category-discrimination tasks in Experiment 3. These results are aggregated over the two Spanish-speaking university populations, given that no significant differences were found between them. Error bars represent standard errors. Twenty-five percent reflects chance performance.

FIU bilinguals tested in Spanish and UTEP bilinguals tested in Spanish.

When analyzed in terms of these planned comparisons, two significant effects of language group were obtained. In particular, the first comparison described above was significant, $F(1, 290) = 4.52, p < .05, MSE = 3988.51$, indicating better overall performance in an English language context than in a Spanish language context. Second, this comparison interacted with motion type, $F(1, 290) = 4.62, p < .05, MSE = 3988.51$, indicating an effect of linguistic context on performance in the manner-discrimination task, $F(1, 145) = 9.25, p < .01, MSE = 3941.52$, but not on performance in the path-discrimination task, $F(1, 145) = 0.00, p > .10, MSE = 4035.50$. Follow-up analyses indicated that bilinguals tested in a Spanish language context performed worse on the manner-of-motion category discrimination than did either monolingual English speakers, $F(1, 88) = 6.57, p < .05, MSE = 3691.29$, or bilinguals tested in an English language context, $F(1, 118) = 7.70, p < .01, MSE = 3580.76$.

There were no other significant effects involving the language group variable (all $p_s > .05$). The lack of significant effects involving the second planned comparison indicates that bilingual Spanish/English speakers exhibited similar patterns of attention as did monolingual English speakers when both groups were tested in

Table 2
 Contrast Weights for the Orthogonal Planned Comparisons
 Involving Language Group in Experiment 3

Language group	Contrast			
	1	2	3	4
Monolingual English speakers	1/3	1	0	0
FIU bilinguals tested in English	1/3	-1/2	1	0
FIU bilinguals tested in Spanish	-1/2	0	0	1
UTEP bilinguals tested in English	1/3	-1/2	-1	0
UTEP bilinguals tested in Spanish	-1/2	0	0	-1

Note. FIU = Florida International University; UTEP = University of Texas at El Paso.

English. The lack of significant effects involving the third and fourth planned comparisons indicates that the two bilingual populations exhibited quite similar category-discrimination performance.

Effects of age of acquisition on bilingual performance. To examine the effects of age of acquisition of English (AoA) on category-discrimination performance, a median split was performed on the bilingual data from Experiment 3, breaking these data down by AoA. The median AoA in this sample was 5 years, and thus participants who were exposed to English on or before 5 years of age ($n = 133$) were considered to be early learners of English, whereas participants who were exposed to English after 5 years of age ($n = 96$) were considered to be late learners of English. Eleven additional participants chose not to answer questions regarding AoA on the postexperimental questionnaire and thus were excluded from this analysis.

Figure 7 depicts the results of Experiment 3, broken down by language context and AoA. An ANOVA was conducted on these data with learning block (1–6), language context (English vs. Spanish), type of motion (path vs. manner of motion), and AoA (early vs. late) as independent variables. This analysis revealed a significant main effect of learning block, $F(5, 1105) = 111.15$, $p < .001$, $MSE = 332.33$, indicating that performance improved across the six blocks of trials. It also revealed a significant interaction of language context and type of motion, $F(1, 221) = 4.95$, $p < .05$, $MSE = 3824.73$, indicating that the effect of language context was greater in the manner-of-motion condition than in the path condition. These effects were moderated, however, by a significant four-way interaction of learning block, language context, type of motion, and AoA, $F(5, 1105) = 2.53$, $p < .05$, $MSE = 332.33$. Follow-up analyses revealed that in participants who were tested on the manner-of-motion discrimination in a Spanish language context, there was a significant main effect of AoA, $F(1, 54) = 4.76$, $p < .05$, $MSE = 2862.24$, as well as a significant interaction of AoA and learning block, $F(5, 270) = 3.40$, $p < .01$, $MSE = 311.29$. There were no significant main effects or interactions involving AoA with any other combination of motion type and language context, indicating that AoA had no effect on performance in the path condition and no effect on performance in an English language context.

Simple effects analyses were conducted to examine the interaction of AoA and learning block for participants who were tested on the manner-of-motion discrimination in a Spanish language con-

text. These analyses revealed that whereas there were no significant differences between early and late learners of English in the first two blocks of trials, an ordinal advantage to early learners of English is evident by the third block of trials, with this advantage approaching significance in Block 4, $t(54) = 1.82$, $p = .08$, and attaining significance in Block 5, $t(54) = 2.32$, $p < .05$, and Block 6, $t(54) = 2.67$, $p < .01$. Indeed, the performance of early bilinguals tested in a Spanish language context only differed significantly from that of monolingual English speakers on the second block of trials, $t(64) = 2.60$, $p < .05$. In contrast, late bilinguals tested in a Spanish language context performed significantly worse than monolingual English speakers throughout the manner-discrimination task (all $ps < .05$).

Correlational analyses were also conducted in which AoA was treated as a continuous rather than a categorical variable. These analyses revealed that among bilinguals who were tested on the manner-of-motion discrimination in a Spanish language context, there was a significant negative correlation between AoA and performance on the final block of trials, $r(56) = -.37$, $p < .01$, as well as between AoA and average performance across the six blocks of trials, $r(56) = -.29$, $p < .05$. These results indicate better ultimate and overall performance, respectively, in bilinguals who were exposed to English at an earlier age.

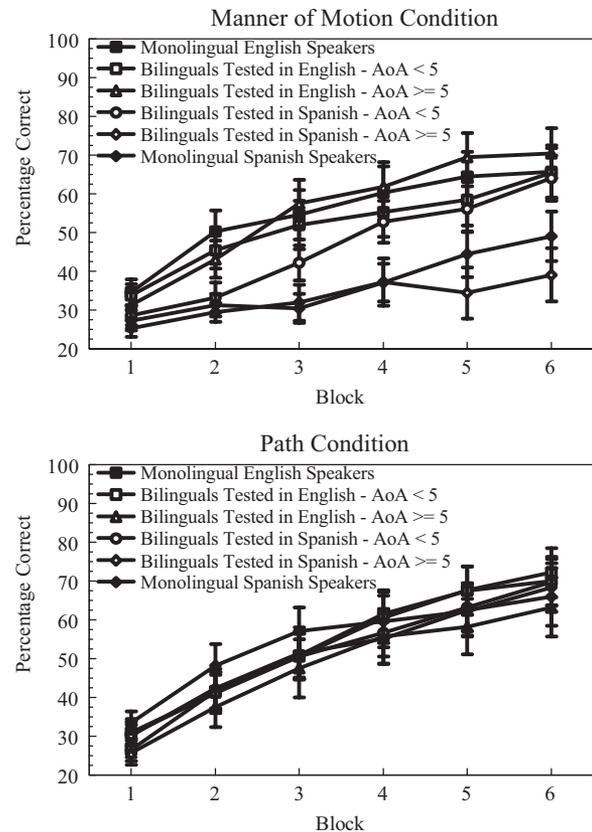


Figure 7. Results of the manner-of-motion and path category-discrimination tasks in Experiment 3, with bilinguals divided up on the basis of the age at which they were exposed to English. The results of monolingual Spanish speakers from Experiment 2 are also included for comparison. Error bars represent standard errors. Twenty-five percent reflects chance performance. AoA = age of acquisition of English.

To illustrate this relationship, Figure 8 represents the manner-discrimination performance (i.e., the average percentage correct across the six blocks of trials) of individual bilingual participants who were tested in a Spanish language context, together with the performance of monolingual English speakers for comparison. Participants who never discovered the predictiveness of manner of motion for category membership would be expected to fall in the region around 25% correct. Participants who discovered this relationship, on the other hand, would be expected to score above 25% correct, with higher percentages of correct answers in participants who discovered this relationship earlier in learning. As can be seen, a significant number of monolinguals and bilinguals who were exposed to English at an early age discovered the relationship between manner of motion and category membership, often quite early in learning. Only three bilinguals who were exposed to English after the age of 6, however, exhibited performance that was significantly above 25% correct. These results suggest that bilinguals who were exposed to English early in life exhibit similar levels of attention to manner of motion as do monolingual English speakers, even when bilinguals are tested in a Spanish language context. Bilinguals who were exposed to English later in life, on the other hand, exhibited much reduced attention to manner of motion when tested in a Spanish language context.

Discussion

The results of Experiment 3 replicated the advantage of English speakers over Spanish speakers on a category discrimination involving manner of motion. Experiment 3 also revealed an influence of the immediate linguistic context on the performance of bilingual Spanish/English speakers, especially in the case of bilinguals who were exposed to English after the age of 5. In particular,

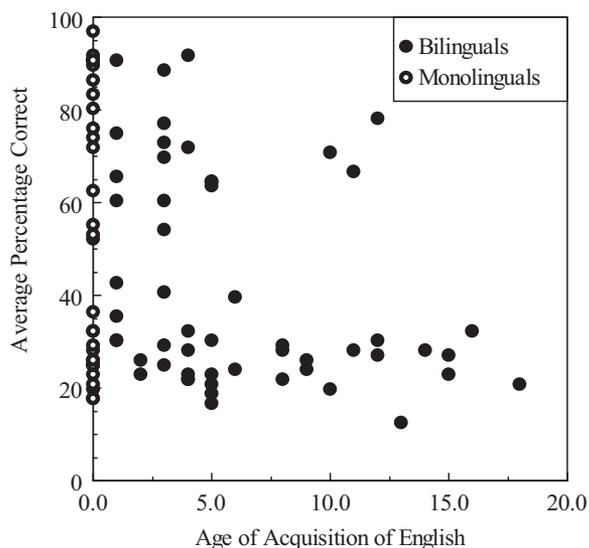


Figure 8. Scatterplot relating one's age of acquisition of English to one's overall performance on the manner-of-motion category discrimination (i.e., aggregated over the six blocks of trials) in Experiment 2. Open circles represent monolingual English speakers, whereas filled circles represent bilingual Spanish/English speakers who were tested in Spanish. Twenty-five percent reflects chance performance.

bilinguals tested in an English language context performed nearly identically to monolingual native English speakers, whereas bilinguals tested in a Spanish language context attended less to manner of motion than did either monolingual native English speakers or bilinguals tested in an English language context. This result suggests that bilinguals have distinct patterns of attending associated with their two languages, attending more strongly to manner of motion in the context of a language in which that attribute is prominently marked. The implications of these results for theories of bilingualism are explored further in the General Discussion.

General Discussion

The results of this research provide evidence that monolingual English speakers and bilingual Spanish/English speakers tested in an English language context attend more strongly to manner of motion than do monolingual Spanish speakers and bilingual Spanish/English speakers tested in a Spanish language context. These results suggest that English language-learning experience, coupled with an English language context, encourages attention to manner of motion, consistent with linguistic relativity. Although the categories to be learned were given novel linguistic labels in Experiment 1, thus allowing one to construe the task as a word-learning task, the same pattern of results was obtained in Experiments 2 and 3 in the absence of novel linguistic labels. These results suggest that attention to manner of motion in English speakers is a general phenomenon and not limited to a word-learning context.

The present results suggest that English speakers conceptualize motion events differently than do Spanish speakers, even outside of a context that demands overt language production. Motion event conceptualization thus joins color perception (Roberson et al., 2000), spatial perception (Levinson, 1996), object categorization (Lucy & Gaskins, 2001), gender classification (Boroditsky et al., 2003; Sera et al., 2002), and conceptions of time (Boroditsky, 2001), among others, in demonstrating effects of one's native language on nonlinguistic cognition, consistent with the linguistic relativity theory.

Although a growing body of research thus provides evidence that speakers of different languages differ to some extent in their perceptions and conceptions of the environment, the magnitude and generality of these effects remain unclear. Despite these positive demonstrations of effects of language on nonlinguistic cognition, there have also been a number of negative findings (e.g., Chen, 2007; January & Kako, 2007; Li, Dunham, & Carey, 2009; Li & Gleitman, 2002), suggesting that linguistic relativity effects may sometimes be overshadowed by more general influences on cognitive performance. Moreover, it remains possible that some demonstrations of linguistic relativity effects may reflect attempts by speakers of different languages to make sense of an unusual experimental situation (Pinker, 1994). In the face of uncertainty, participants may resort to linguistic mediation, labeling experimental stimuli to better classify them. If this account is correct, then effects of one's native language may be limited to high-level problem-solving tasks, and speakers of different languages may otherwise perceive the world quite similarly.

Even if linguistic relativity effects are limited to problem-solving tasks, however, humans spend a nontrivial amount of time engaged in such tasks, and thus effects of one's native language on high-level problem-solving are still of considerable interest. More-

over, even if linguistic relativity effects are limited to contexts in which participants engage in covert labeling, humans may engage in such covert use of language quite frequently, and thus one's native language may influence cognitive performance in a variety of different contexts. Therefore, rather than attempting to preclude any possibility of linguistic mediation on the part of participants and arguing about whether or not a given effect is strong enough and general enough to count as a "Whorfian" effect, a more constructive approach may be to attempt to document the various conditions under which one does and does not see effects of language on cognition. Such an investigation of the boundary conditions for linguistic relativity effects may yield a more detailed understanding of the bidirectional, complex relationship between language and more general cognitive performance.

The Roles of Path and Manner of Motion in the Conceptualization of Motion Events

The present results are consistent with the view that some attributes of events are universally attended to and incorporated into linguistic descriptions of those events, whereas others are optionally attended to and encoded. Path appears to fall into the former category, whereas manner of motion appears to fall into the latter. A number of findings support this account. First, all languages appear to encode path information in one form or another. Indeed, Slobin (2004) has proposed that "because path is an obligatory component of motion event expressions, we can't compare languages in terms of the accessibility of path as a category: without a path verb or satellite or other path element, there is no motion event" (p. 238). In contrast, manner of motion is more likely to be conveyed in some languages than in others and is conveyed at a finer level of granularity in some languages than in others.

Second, there is evidence that children learn path terms earlier than manner-of-motion terms, even in languages in which both types of information are prominently marked. In particular, the first relational terms learned by English-speaking children are typically not manner-of-motion verbs but, rather, are path prepositions and verb particles such as "in," "out," "up," and "down" (Bowerman, 1978; Farwell, 1977; Gentner, 1982; Gopnik & Choi, 1995; McCune-Nicolich, 1981; Nelson, 1974; Smiley & Huttenlocher, 1995; Tomasello, 1987). In fact, English-speaking children start to use these path prepositions and verb particles at about the same time that children speaking path-verb languages (e.g., Korean) start to use verbs (Choi & Bowerman, 1991). In contrast, English-speaking children typically learn to use manner-of-motion verbs only later.

Third, even adult speakers of English seem to treat path information as being more important to the meaning of an event than is manner-of-motion information. In particular, Kersten (1998a, 1998b, 2003) found in a number of experiments that adult English speakers associated a novel verb more strongly with path information than with manner-of-motion information when both were potential referents of the verb. On the basis of this result, Kersten (1998a) proposed that the prototypical relational term encodes the motions of an object with respect to an external reference point, such as another object. In contrast, manner-of-motion information may be more useful in distinguishing different classes of objects,

which have different ways of moving their parts in relation to one another when in motion (see also Kersten & Billman, 1997).

If this account is correct, it would suggest that manner of motion is much more likely than path to exhibit linguistic relativity effects of the type exemplified in the present research. This would explain the equivalent performance on a path-discrimination task by English speakers and Spanish speakers in the present experiments. Although there have been studies (e.g., Gennari et al., 2002) showing that Spanish speakers were under some conditions more likely than English speakers to choose the same-path alternative in a similarity task, participants in this task had to choose between a same-path alternative and a same-manner alternative. Thus, if English speakers were more likely than Spanish speakers to choose the same-manner alternative, this would necessarily make them less likely to choose the same-path alternative. In contrast, in the present research, attending to manner of motion would not necessarily result in reduced attention to path, because both manner of motion and path were competing for attention with a number of other attributes, such as the appearances of the body parts of the two creatures, their absolute locations on the computer screen, and the environment in which the event took place. Thus, attention to manner of motion in English speakers may have come primarily at the expense of attention to these other, nondiagnostic attributes, resulting in little, if any, reduction in attention to path. More generally, the primacy of path as an organizer of motion event conceptualizations may explain why participants in the present experiments learned the path discrimination equally well, regardless of their native language, their status as a monolingual or bilingual, the university they attended, and the language context in which the experiment took place.

Relation to Theories of Bilingualism

The present findings suggest that patterns of attending in bilinguals are dependent upon both the circumstances of bilingualism and the context in which attention is being measured. With regard to the circumstances of bilingualism, bilingual Spanish/English speakers who were exposed to English before the age of six exhibited category-discrimination performance that was quite similar to that of monolingual English speakers. These early bilinguals performed nearly identically to monolingual English speakers on the manner-discrimination task when both groups were tested in an English language context. Furthermore, when tested on the manner-discrimination task in a Spanish language context, early bilinguals only significantly differed from monolingual English speakers early in learning, with the two groups achieving nearly identical ultimate performance. These results thus suggest that bilinguals who are exposed to English early in life exhibit patterns of attending that are quite similar to those of monolingual English speakers, for the most part independent of linguistic context.

These results can be interpreted with respect to the theory of Ameel, Storms, Malt, and Sloman (2005), who proposed that regardless of the linguistic context in which they are tested, bilinguals classify stimuli on the basis of category boundaries that reflect a compromise between the category boundaries imposed by their two languages. For example, when asked to classify household containers as either bottles or jars, bilingual speakers of Dutch and French classified the containers differently than did monolingual speakers of either of those languages. Thus, one would expect

a bilingual Spanish/English speaker in the present experiments to classify objects and events in terms of categories that reflect a compromise between the categories imposed by Spanish and English.

The linguistic classification of paths is similar in Spanish and English, with path categories labeled by verbs in Spanish closely resembling the path categories labeled by verb particles and prepositions in English. The linguistic classification of manners of motion differs in Spanish and English, however, with English dividing up the space of manners of motion into a larger number of categories. For example, the English verbs “jump,” “hop,” “leap,” and “bound” all map onto the single Spanish verb “saltar” (Slobin, 2006). Thus, a bilingual Spanish/English speaker would be expected to make a larger number of distinctions when classifying manners of motion than would a monolingual Spanish speaker but perhaps not as many distinctions as a monolingual English speaker.

Although the novel manners of motion employed in the present research would be difficult to distinguish in terms of existing manner-of-motion categories, one’s learning of new categories may be guided by the set of categories one already knows (Kersten, Goldstone, & Schaffert, 1998; Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002). Thus, if one has learned to classify real-world manners of motion on the basis of subtle distinctions in the way an object moves around, one may also look for subtle distinctions when learning to classify novel manners of motion. Participants with greater (i.e., earlier and longer) exposure to the English language would thus be expected to look for finer distinctions when classifying novel manners of motion than would participants with less exposure to the English language. This theory thus accounts for the advantage of early bilinguals over late bilinguals in the manner-of-motion category discrimination.

The theory of Ameel et al. (2005) was formulated to account for the behavior of compound bilinguals, and the authors suggested that their theory may not apply to other classes of bilinguals, such as subordinative bilinguals, who are exposed to one language from birth and a second language only later in life. The late bilinguals in the present study fall into the latter category, and the classification behavior of these bilinguals was indeed quite different from that of early bilinguals. In particular, the performance of late bilinguals in the manner-discrimination task was much more strongly affected by linguistic context than was the performance of early bilinguals, with late bilinguals attending more strongly to manner of motion in an English language context.

It may be possible to explain these results in terms of Grosjean’s (2001) theory of multiple language modes in bilingual speakers. This theory suggests that the relative activation of a bilingual’s two languages will vary in different contexts. For example, some contexts (e.g., conversing with a monolingual speaker or speaking in a formal setting) may encourage a monolingual language mode, leading to suppression of the other language and thus relatively little code switching. Other contexts, on the other hand, may lead to a more bilingual language mode, leading to activation of both languages and thus frequent code switching (e.g., the fourth author has observed frequent code-switching among Spanish/English bilinguals outside of class on the FIU campus, where English is the official language but the majority of students are native Spanish speakers).

In the present research, Spanish conversations with the experimenter in the presence of other native Spanish speakers, coupled with the presentation of the instructions and stimuli for the experiment in Spanish on the computer screen, may have pushed late bilinguals toward a monolingual Spanish language mode. Given that manner of motion is not prominently marked in Spanish, this may have resulted in reduced attention to manner of motion in the category-discrimination task, leading to difficulty when only manner of motion could be used to discriminate the categories. In contrast, English conversations with the experimenter, in an English language university laboratory, coupled with English presentation of the instructions and stimuli on the computer screen may have led to greater English language activation in late bilinguals, encouraging greater attention to manner of motion. Thus, late bilinguals’ conceptualizations of objects and events may have been influenced by the linguistic context and the resulting language mode that it encouraged.

A possible mechanism underlying effects of linguistic context on categorization behavior in late bilinguals can be derived from Smith and Samuelson’s (2006) proposal of an attention learning mechanism. According to this theory, children learn at an early age that different combinations of perceptual and linguistic cues are indicative of different patterns of category organization. For example, in the context of a rigid object with angular, complex parts (typically an artifact), accompanied by a sentence involving a novel noun in the direct object position (again typical for artifacts), children’s attention is typically drawn to the shape of the object, because shape is highly diagnostic of category membership for artifacts. In contrast, when presented with an object with eyes, legs, and a head (typically an animate creature), accompanied by a sentence involving a novel noun in the subject position (again typical for animate creatures), children’s attention is drawn to multiple attributes, including texture and shape. Thus, attention is drawn to particular attributes as a function of previously learned associations between particular perceptual and linguistic cues and patterns of category organization.

How might this mechanism explain the behavior of late bilinguals in the present experiments? When initially learning Spanish in the absence of English language exposure, manner of motion may not be particularly diagnostic of category membership, varying orthogonally to another, potentially more salient attribute of events (i.e., path), and receiving infrequent mention in language. Thus, attention would presumably be drawn to path at the expense of manner of motion when confronted with an event to be categorized. Upon later learning of English, however, these individuals may discover that in an English language context, especially in the presence of animate objects involving multiple, interacting parts, attention to manner of motion is sometimes necessary to correctly categorize an event. As a result of learning these associations between particular linguistic (i.e., English) and perceptual (i.e., animate object) contexts and the utility of manner of motion as a principle of category organization, attention may come to be deployed to manner of motion whenever this combination of contextual cues is present. In contrast, when presented with a different combination of contextual cues (e.g., a Spanish language context), attention to manner of motion may be weak or nonexistent, because of the prior lack of diagnosticity of manner of motion in this context. It is important to note that this attentional deployment is thought to be elicited automatically by particular combi-

nations of contextual cues, regardless of whether or not one has the intention to speak about or label those cues. Thus, if this explanation is correct, effects of linguistic context on the attentional preferences of late bilinguals are entirely consistent with linguistic relativity theory.

How might one then explain the smaller effects of linguistic context on the categorization performance of early bilinguals? The attention learning mechanism of Smith and Samuelson (2006) suggests that linguistic context may have been less salient or diagnostic of category organization in the early learning experiences of these individuals. For example, an individual growing up in a bilingual environment may witness and participate in frequent code-switching, making it difficult to differentiate English and Spanish language contexts. The attentional preferences of a bilingual growing up in such an environment may thus be under the joint control of his or her two languages, resulting in attention to attributes that have previously been discovered to be diagnostic of category membership in either language. It is difficult to determine if the environments of the early bilinguals in the present study can indeed be characterized in this way, but it is certainly plausible to propose that bilinguals who are exposed to two languages at an early age experience reduced separation of the contexts in which the two languages are heard. Linguistic relativity effects may thus be more difficult to observe in early bilinguals than in monolinguals or late bilinguals, because cognitive performance in early bilinguals may generally reflect the influences of multiple languages.

Conclusions

The present experiments provide evidence that the greater prominence given to manner of motion in English than in Spanish encourages speakers of English to attend to this attribute, even in a context in which overt speech is not required. These results are consistent with linguistic relativity theory, suggesting that attentional preferences developed in the context of language learning lead to more general differences in cognitive performance between monolingual speakers of different languages. Moreover, the cognitive performance of bilinguals may reflect the influences of both of their languages. In particular, bilinguals who learned two languages early in life may exhibit attentional preferences that reflect the combined influences of both languages. Bilinguals who learned one language early in life and one later, on the other hand, may exhibit distinct patterns of attending in the two language contexts. It may thus be possible to observe linguistic relativity effects in an individual bilingual speaker.

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