The Roles of Motion and Moving Parts in Noun and Verb Meanings

Alan W. Kersten
School of Psychology
Georgia Institute of Technology
Atlanta, GA 30332-0170
phone: (404) 853-0192
psg90ck@gitvm1.gatech.edu

Dorrit Billman
School of Psychology
Georgia Institute of Technology
Atlanta, GA 30332-0170
phone: (404) 894-2349
billman@pravda.cc.gatech.edu

Abstract

This study contrasts the learning of two different kinds of motion. The first of these we call extrinsic motion, or the motion of one object with respect to another, reference object. The second we call intrinsic motion, or the motion of an object or its parts expressed with respect to the object itself. An experiment tests for people's abilities to associate these two types of motion with nouns and verbs. Subjects were presented with animated events on a computer screen accompanied by sentences involving nouns and verbs. In the learning phase, each noun and verb was related to both an extrinsic motion attribute and an intrinsic motion attribute. Subjects were then tested by presenting them with pairs of events varying on only one of these attributes and asking them which event better exemplified the meaning of a particular noun or verb. The results of this experiment demonstrate a bias to associate verbs with extrinsic motion and to associate nouns with intrinsic motion. These results suggest a division of labor between noun and verb meanings, with verb meanings specialized to encode relational information, while noun meanings are specialized to encode information about objects in isolation.

Introduction

All of the world's languages seem committed to expressing meaning through combinations of lexical items, either morphemes or independent words. Of course, there are many words such as "baseball" that are associated with a myriad of notions about the culture in which they are used and the functions their referents fulfill (e.g., national pastime, can be hit by a bat or thrown, etc.). There seem to be no languages, however, that employ individual words to describe entire events even at relatively low levels of specificity, such as "the motion of a small mammal into an enclosure in a stealthy manner." Yet we can effortlessly express the same idea in greater detail using combinations of words, such as nouns, verbs, and prepositions, as in "The fox skulked into the henhouse."

Expressing meaning through combinations of words would seem most efficient if different words contributed different aspects of meaning to the expression, eliminating redundancy through division of labor. This paper will explore a seeming division of labor between nouns and verbs in the expression of one particular type of meaning, namely the description of motion. We will begin by trying to convince you that the division of labor proposed by your elementary English teacher - nouns label people, places, or things, leaving to verbs the description of motion was in fact wrong, or at least overly simplistic. After arguing that nouns do indeed play a role in the description of motion, we will go on to describe the role of the verb, noting how this role may be different from that of the noun. We will then describe an experiment designed to test for the division of labor proposed in the introduction.

One tends not to think of motion when one thinks about noun meanings. Nouns are generally thought of as labels for objects, with each common noun seemingly labeling a different category of objects. Tversky and Hemenway (1984) have provided evidence that different basic-level object categories are primarily distinguished based on their parts, and thus, determining which noun or nouns are applicable to a particular object requires an examination of the parts of that object. As argued by Tversky and Hemenway (1984), however, good parts are those that have functional as well as perceptual significance. One function that would seem particularly important to animate objects is motion. For example, the legs and arms of human beings function to provide locomotion for the human body. Thus, the noun "human" may be associated not only with arms and legs but also the motion they provide. Some evidence for this claim comes from work by Johansson (1973). He presented observers with points of light representing various points on the bodies of walking humans. When presented with a static image of these points, no observer identified the points as being representative of human bodies. When these points were displayed in motion, however, every observer was almost instantly able to recognize human locomotion. Thus, these observers were apparently able to categorize and label human beings based only on the relative motions of their body parts.

The work of Barr and Caplan (1987) suggests a further role of motion in noun meanings. They propose two different types of features in object category representations. One type they call intrinsic features, which are characteristics that are true of an object when considered in isolation, such as object parts. Adopting Barr and Caplan's (1987) terminology, we can define *intrinsic motion* as the motion of an object that can be described in terms of the object itself, such as the relative motions of parts of the object. Barr and Caplan (1987) call the second type extrinsic features, or features that involve relations between objects. For example, "used to work with" is offered as an extrinsic feature of a hammer, describing a relation between a hammer

and a human. We can similarly characterize *extrinsic motion* as the motion of an object relative to another object. Extrapolating from Barr and Caplan's (1987) distinction, we would predict that both intrinsic and extrinsic motion play a role in object categories and the meanings of nouns that label them. Thus, the meaning of "cat" may include information not only about how a cat's legs move relative to its body to produce motion, but also that cats tend to chase mice and run away from dogs.

Nelson (1983) has proposed, however, that noun meanings are first formed around objects that play the same role within an event, only later noticing perceptual similarities of fillers of this role. For example, a child may first use "cat" to label those things that have played the role of "chaser" in events involving mice. This theory thus predicts that people should first associate nouns with extrinsic motion, as roles within an event seem to involve relations between objects.

Unlike nouns, verbs are generally regarded as conveying motion. Different verbs convey different types of motion, however. These differences are especially evident when one compares across languages. According to Talmy (1985), the most common type of verb across languages is the path-specifying verb. Examples of this verb in English are "enter", "exit", "ascend", and "descend". Such verbs seem to convey extrinsic motion, with the first two describing motion into and out of some reference object, and the second two describing motion away from and toward the earth, respectively. In contrast, the most common verb type in English, and second most common type across languages is the manner-specifying verb (Talmy, 1985). Examples of this type of verb are "run", "walk", "stroll", and "saunter". Jackendoff (1987) has proposed that such verbs convey object-internal motion, similar to our notion of intrinsic motion, describing different ways of moving body parts to achieve locomotion, but providing no information about path.

Although the majority of English verbs seem to convey intrinsic motion, young children learning English seem to prefer using relational terms that convey extrinsic motion. Namely, children of around 14 months of age start to use path-specifying prepositions such as "in", "out", "up", and "down", often well before they first start using verbs. Interestingly, children learning Korean start to use verbs at about the same point in development that children learning English start to use these prepositions, and use them in the same situations that English-speaking children use prepositions (Choi & Bowerman, 1991). Like English prepositions and unlike English verbs, these Korean verbs are path-specifying, describing extrinsic motion.

These findings provide evidence for a bias to associate relational terms with extrinsic motion. Such a bias would facilitate the learning of verbs in many languages and prepositions in English, but would have to be overcome to learn many verbs in English, accounting for the delayed acquisition of these verbs relative to prepositions and verbs in other languages. Given such a bias, a sensible division of labor between nouns and verbs in the description of motion would seem to require a bias to associate nouns with intrinsic motion. Such a bias would facilitate the association of nouns with the relative motions of body parts, as was found by Johansson (1973). It would, however, be inconsistent with Nelson's (1983) theory.

The following experiment tested the prediction that nouns tend to be more strongly associated with intrinsic motion than with extrinsic motion, and that verbs tend to be more strongly associated with extrinsic motion than intrinsic motion. To this end, we used computers to create animated events involving two characters, one of which moved throughout the course of the event. Each event was accompanied by a sentence involving a novel noun and verb. During learning, each noun and verb was associated with one value of each of several attributes, as depicted in Figure 1. Most crucially, each noun and each verb was associated with one value of an intrinsic motion attribute, the leg motion of the moving character, and one value of an extrinsic motion attribute, the path of the moving character relative to the other character.

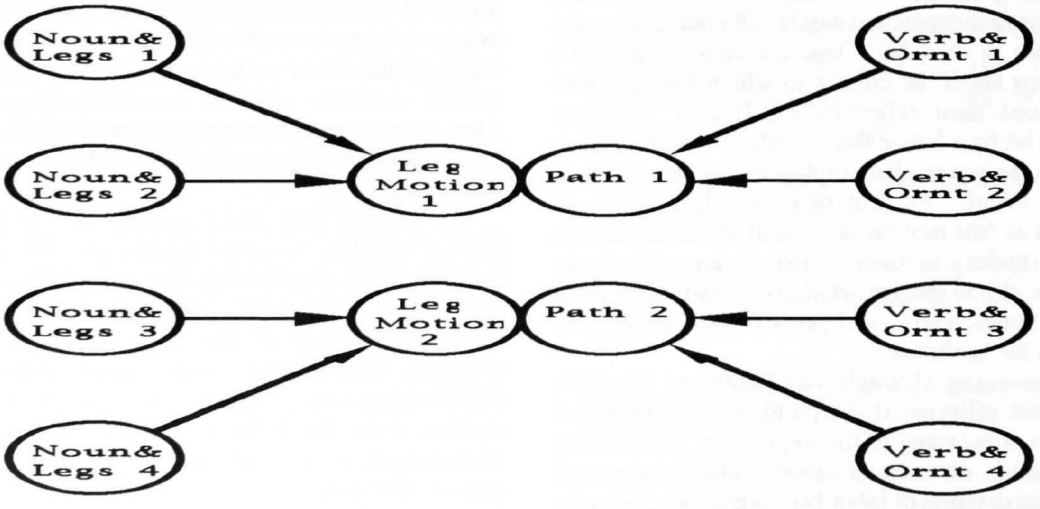

Figure 1. Schema for learning events seen by subjects for whom legs differentiated the four nouns. Orientation differentiates the four verbs here, while each leg motion and path is associated with two nouns and two verbs.

After a number of learning events, knowledge of these relations was tested by presenting subjects with pairs of events that differed on the value of only one of the relevant attributes, asking the subject to indicate which of the two events better exemplified the meaning of a particular noun or verb. Subjects were predicted to more strongly associate nouns with leg motion than with path, and to more strongly associate verbs with path than with leg motion. Learning to associate nouns with leg motion, however, may require those nouns to also be associated with the appearances of the legs carrying out that motion. To test this conjecture, nouns were associated with legs for half of the subjects, as depictedin Figure 1, while they were associated with heads for the other half. We predicted that subjects would show more learning of the relation between nouns and leg motions when those nouns were related to legs than when they were related only to heads.

Method

Subjects

Sixty undergraduates at the Georgia Institute of Technology received course credit for participation in this experiment.

Stimuli

All Events. The events were displayed on Macintosh II computers using MacroMind Director 2.0. Two characters appeared in each event. Each character was composed of three attributes: *head*, *body*, and *legs*. Each of these attributes had four possible values. In addition, one of the characters, the *agent*, moved throughout the course of the event, while the other, the *patient*, remained stationary. An agent's motion could be described by three attributes. One was the path of the agent, or the direction(s) taken by the agent relative to the patient. A second motion-related attribute was the leg motion of the agent. Schematic descriptions of the values of these two attributes are shown in Figure 2. A third motion-related attribute was the orientation of the agent as it moved. Some agents moved in the directions they faced, some moved backwards, some moved to the left, and some moved to the right. A static background was also present in each event. The four backgrounds were a swamp, a desert, a mountain scene, and a rocky plain.

Learning Events. There were 80 learning events. Each learning event was accompanied by a spoken sentence presented by the computer. Each sentence involved a novel *noun*, preceded by "the", and a novel *verb*, preceded by "is" and followed by "-ing". There were four different nouns and four different verbs. Throughout learning, each noun always accompanied a particular value of one of the body parts of the agent. For half of the subjects, this was the head, while for half, it was the legs. Each verb was always accompanied by a particular orientation by the agent. Thus, one verb corresponded to moving forwards, one to moving backwards, and so on. Two attributes, leg motion and path, were related to both nouns and verbs. This was accomplished by presenting each subject with only two of the four possible values of each of these attributes, with the choice of which two values to be presented and how these values related to the noun and verb determined randomly for each subject. Each value of each of these attributes was associated with two of the nouns and two of the verbs. Values for other attributes were assigned randomly in each event.

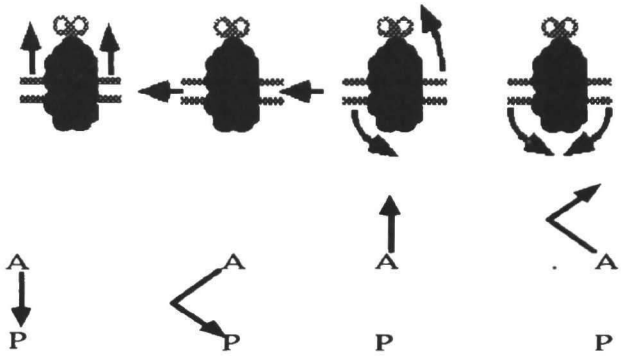

Figure 2. Values of leg motion (top) and path (bottom) in this experiment. The A and P on the bottom represent the agent and patient, respectively.

Word Meaning Test Events. There were 24 trials testing the meanings of individual words. Each trial involved a forced choice between two events, so that there were 48 events during this part of the experiment. During each test trial, one event was presented, accompanied by a spoken question about the meaning of an individual noun or verb, asking "Is this" and followed either by "a" and a noun or by a verb followed by "-ing". During the second event, a subject was asked the same question as in the first event, after which (s)he had to choose which event better exemplified the meaning of the word accompanying the event. In each trial, one event was entirely correct while the other event had one attribute whose value mismatched the meaning of the noun or verb accompanying the event. Each trial thus tested the association of one attribute with a noun or a verb. Twelve trials tested for knowledge of nouns, 4 testing associations with either heads or legs, 4 testing associations with leg motions, and 4 testing associations with paths. Twelve other trials tested for knowledge of verbs, 4 testing associations with orientations, 4 testing associations with leg motions, and 4 testing associations with paths.

Novel Combinations Test Events. After the word meaning test trials, there were 16 trials testing for interpretations of sentences involving nouns and verbs not found together during learning. For example, Noun 1 and Verb 3 in Figure 1 would have been paired together only in a novel combinations trial. The reason why such nouns and verbs had not been paired together during learning was that they had been associated with different values of leg motion and path. Thus, when used together in a sentence, they

made conflicting predictions for the values of those attributes. Each novel combinations trial involved two events. In one event, the values of leg motion and path were consistent with the meaning of the verb in the sentence accompanying the event. In the other event, one of these two attributes took a value consistent with the noun, while the other took a value consistent with the verb. At the end of each trial, subjects were asked to choose which of the two events better exemplified the meaning of the sentence. A subject thus had to decide whether the noun or verb was more important in predicting the value of the attribute varying across events. Eight trials varied leg motion, while 8 varied path. In every event, the value of either agent legs or agent head was consistent with the meaning of the noun, while the value of orientation was consistent with the meaning of the verb.

Procedure

Subjects were instructed that they were to view a number of events depicting life on another planet, and that they were to learn the meanings of words accompanying those events. Subjects were then presented with 80 learning events. After each learning event, the subject clicked on a button labeled "Next Event" to continue. At the end of learning, subjects were instructed that they were to be tested on their knowledge of the nouns and verbs heard during learning. Subjects were then presented with 24 word meaning test trials, each involving 2 events. At the end of the first event in each trial, the subject clicked on the "Next Event" button to see the second event in the trial. At the end of the second event, subjects pressed one of three buttons. One button, labeled "Repeat" allowed subjects to view the two events in the trial again. The other two buttons were labeled "First Event" and "Second Event", allowing the subject to indicate which event was the better example of the word accompanying the events. Subjects were then presented with the 16 novel combinations trials, following the same procedure.

Design

The primary dependent measure in this experiment was accuracy at choosing the correct events in the word meaning test trials. The two within-subjects independent variables were the part of speech of the word accompanying each test trial (noun vs. verb) and the attribute being tested (leg motion vs. path). Manipulated between-subjects was the choice of body part to fully differentiate nouns (head vs. legs).

Results

During the word meaning test trials, subjects were tested 4 times with each combination of part of speech and the attribute being tested, so that chance performance would produce a score of 2. As predicted, subjects more strongly associated nouns with leg motion ($M = 2.60$, $SD = 1.11$) than with path ($M = 2.27$, $SD = 1.18$). This difference was significant, $t(59) = 1.80$, $p < .05$ (one-tailed). Also as predicted, subjects more strongly associated verbs with path ($M = 3.40$, $SD = 1.01$) than with leg motion ($M = 3.03$, $SD = 0.97$). This difference was also significant, $t(59) = 2.18$, $p < .05$ (one-tailed). An ANOVA on these data revealed a significant interaction of part of speech and the attribute being tested, $F(1,58) = 7.70$, $p < .01$, $MSE = 0.95$, as well as a main effect of part of speech, $F(1,58) = 33.75$, $p < .001$, $MSE = 1.09$. Contrary to prediction, the body part associated with nouns had no significant main effect, $F(1,58) = 1.75$, $p > .10$, $MSE = 1.61$, nor any significant interactions, all $Fs < 1.00$. As can be seen in Figure 3, however, subjects showed a tendency to more strongly associate nouns with leg motion when the values of legs were also related to noun meaning ($M = 2.83$, $SD = 1.09$) than when only the values of head could be used to differentiate the four nouns ($M = 2.37$, $SD = 1.10$).

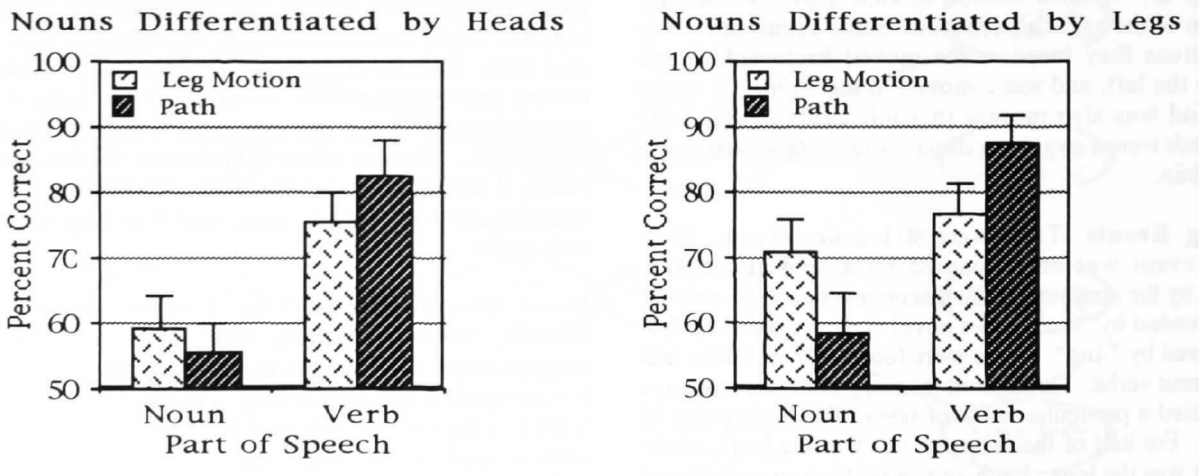

Figure 3. Results of the word meaning test trials.

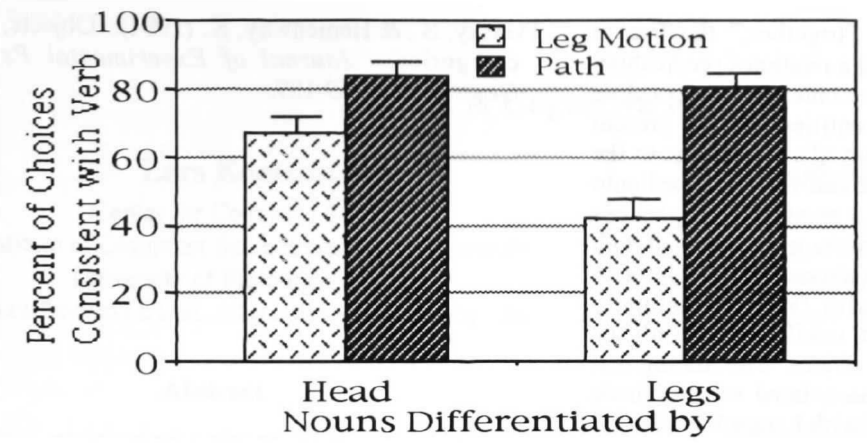

Figure 4. Results of the novel combinations test trials.

Subjects were also tested on relations between nouns and either heads or legs and between verbs and orientations. When heads differentiated nouns, subjects averaged 3.03 (SD = 1.07) on relations between nouns and heads, and 3.23 (SD = 1.01) on relations between verbs and orientations. When legs differentiated nouns, subjects averaged 3.00 (SD = 1.08) on relations between nouns and legs, and 3.03 (SD = 1.13) on relations between verbs and orientations.

In the novel combinations trials, leg motion varied on 8 trials, while path varied on the other 8. These trials were scored for the number of choices consistent with the verb. Thus, if a subject showed no preference for associating an attribute with one part of speech over the other, a score of 4 would be obtained. Choices perfectly consistent with the verb would produce a score of 8, while choices perfectly consistent with the noun would result in a score of 0. Overall, subjects more strongly associated path with verbs than with nouns, with an average score of 6.57 (SD = 1.75). In contrast, subjects showed no preference for associating leg motion with one part of speech over the other, with an average of 4.37 (SD = 2.49). This pattern of results produced a main effect of attribute, $F(1,58) = 33.16$, $p < .001$, MSE = 4.38. The body part associated with nouns had relatively little impact on path scores, with an average of 6.70 (SD = 1.73) when nouns were differentiated by heads and 6.43 (SD = 1.79) when nouns were differentiated by legs. Body part had important consequences for leg motion scores, however (see Figure 4). Subjects averaged 5.33 (SD = 2.31) when heads differentiated the four nouns, compared to an average of only 3.40 (SD = 2.31) when legs played this role. This pattern of results produced significant main effects of body part, $F(1,58) = 8.94$, $p < .01$, MSE = 4.06, and test attribute, $F(1,58) = 33.16$, $p < .001$, MSE = 4.38, as well as a significant interaction of body part with attribute, $F(1,58) = 4.76$, $p < .05$, MSE = 4.38.

Discussion

The results of this experiment provide evidence for a set of biases that function to create a division of labor between nouns and verbs in the description of motion. The finding that nouns were more strongly associated with leg motion than with path may be indicative of a general bias to associate nouns with intrinsic motion. In contrast, the opposite pattern of results with verbs may exemplify a bias to associate verbs with extrinsic motion. It should be noted that progressive forms of the verbs used in these experiments (e.g., "morping") are in some sense more "noun-like" than finite verbs (e.g., "morp"). Progressive forms were used because these seemed most natural in describing actions occurring simultaneously with the accompanying speech. This decision may have *reduced* the differences between nouns and verbs, however, and thus there is reason to believe that the contrasts between nouns and verbs discovered in this experiment are fairly robust.

In contrast to the intuitive definition that verbs label motion while nouns label only objects, leg motion was found in both the word meaning and novel combinations trials to be roughly equally associated with nouns and verbs, at least when the appearance of the legs was also related to noun meaning. Moreover, in novel combinations trials where subjects chose the leg motion consistent with the noun, path was always consistent with the verb, and thus they chose a novel combination of leg motion and path over a familiar combination seen during learning. Without the influence of path, subjects may have been even more willing to choose the leg motion consistent with noun over that consistent with the verb. This issue is also being explored in other work. In addition, the finding that subjects chose leg motions consistent with the noun more often when legs differentiated the four nouns provides evidence that associations between nouns and motions may be mediated by the parts carrying out those motions. This is reasonable given that real-world nouns are associated with manners of motion only because the objects labeled by those nouns have evolved particular configurations of body parts that are conducive to motion.

The finding that intrinsic motion is associated with both nouns and verbs is consistent with Langacker's (1990) notion of a nominal predication. According to Langacker, nominal predications (e.g., nouns) differ from relational predications (e.g., verbs) not in their content, but rather in how this content is construed. Langacker offers as an

example the terms "group" and "together," the first a nominal predication and the second a relational predication. These predications reflect the same content, namely a close configuration among a number of entities. In the present experiment, body parts may have played a similar role to the entities in this example, with nouns and verbs mapped onto the configuration of body parts of a creature. Langacker's theory can also explain why nouns were not associated with extrinsic motion, as nominal predications are thought of as bounded entities. These boundaries fall most naturally around the extent of the object itself, ruling out any influence of an external, reference object. The finding that nouns and verbs were *equally* associated with intrinsic motion, however, seems to conflict with Langacker's theory. In this theory, relational predications place primary emphasis on the interconnections between entities, while nominal predictions emphasize the entities themselves. This would seem to predict that information about the relation between the legs and body of a creature would always be more strongly associated with verbs than with nouns. This pattern of results was found only when the appearance of the legs was random.

In summary, this work provides a new experimental method for studying differences between nouns and verbs. This method could be very useful in understanding how these two different types of concept are represented and how these representations interact in the production and interpretation of sentences. This study provides evidence that motion is not exclusively represented in verb meanings, but rather that nouns and verbs must work together to this end.

References

Barr, R.A., & Caplan, L.J. (1987). Category representations and their implications for category structure. *Memory and Cognition, 15(5)*, 397-418.

Choi, S., & Bowerman, M. (1991). Learning to express motion events in English and Korean: The influence of language-specific lexicalization patterns. *Cognition, 41*, 83-121.

Jackendoff, R. (1987). On beyond zebra: The relation of linguistic and visual information. *Cognition, 26*, 115-122.

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. *Perception and Psychophysics, 14*, 201-211.

Langacker, R.W. (1990). *Concept, image, and symbol.* Berlin: Mouton de Gruyter.

Nelson, K. (1983). The derivation of concepts and categories from event representations. In E. Scholnick (Ed.), *New trends in conceptual representation: Challenges to Piaget's theory* (pp. 129-150). Hillsdale, NJ: Lawrence Erlbaum Associates.

Talmy, L. (1985). Lexicalization patterns: Semantic structure in lexical forms. In T. Shopen (Ed.), *Language typology and linguistic description, Vol. 3: Grammatical categories and the lexicon.* Cambridge University Press: Cambridge.

Tversky, B., & Hemenway, K. (1984). Objects, parts, and categories. *Journal of Experimental Psychology: General, 113*, 169-197.