# 8

# THE BODY AND CHILDREN'S WORD LEARNING

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The body is the conduit of experience into the mind and the final pathway through which ideas have their effect in the world. *Nothing* gets into or out of the cognitive system (or the brain) except through the surface structure of the body. Parts of the body—head, hands, legs, and feet—play a role in every experience, every second, every minute from birth to death. This raises the question of whether and how the morphology of the body—the front end to all cognition—matters to the nature of cognition itself.

Gordon Holmes (1922/1979) documented the representational role of the body early in the history of neuroscience, discovering the organizational system known as the "neural map." This is a topographic array of nerve cells across which there is systematic variation in the value of some sensory-motor parameter. Maps organized by the body's surface are a particularly common form of cortical representation (e.g., Grazianao, Cohen, & Botvinick, 2002; N. P. Holmes, Spence, Giard, & Wallace, 2004; Penfield & Rasmussen, 1950). Studies of neurological disorders and functional brain imaging demonstrate important roles for these body maps in the perception of one's own body (N. P. Holmes et al., 2004), in the production of action (e.g., Gallese, Craighero, Fadiga, & Fogassi, 1999), in the understanding of others' actions, and in the categorization of objects such as tools that are strongly linked to action by a particular body part (Hauk, Johnsrude, & Pulvermüller, 2004).

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Studies of the world's languages also point to body parts as a universal representational medium (e.g., Heine, 1997; Svorou, 1993). Words derived from body parts are remarkably common in semantic domains of space, number, measurement, and emotion (de León, 1994; Lakoff & Johnson, 1980; Sakuragi & Fuller, 2003; Saxe, 1981, N. Yu, 2004). Indeed, researchers have proposed a universal semiotics of body parts to interpret and translate images and texts from ancient cultures (e.g., Bron, Corfu-Bratschi, & Maouene, 1989; see also Lakoff & Johnson, 1980). All this suggests that the body may be more than a mere interface between mind and world; rather, it may be central to the origin and representational basis of meaning.

Accordingly, this chapter considers the role of the body in children's early word learning. Children learn words in the here and now of physical space, through embodied actions of turning eyes and heads to look at things, through the movement of arms and hands to reach and act on things, and in the context of large body movements such as running and jumping. This chapter presents four examples of how processes of early word learning may be derived from and embedded in bodily action. Example 1 concerns the role of the body in the spatial organization of attention and, as a result, in the binding of internal cognitive contents to the external world. Example 2 concerns the role of the body in binding us to the attentional states of others. Example 3 concerns how bodily actions reveal and create meaning. Example 4 considers the role of the body—and its morphology—in the semantic structure of early learned verbs.

## 8.1 EXAMPLE 1: THE BODY AND SPATIAL ATTENTION

As J. J. Gibson (1979) argued, attention is fundamentally about bodily action in space, about orienting the sensors to pick up task-relevant information. The body's position in space—the direction we turn our heads, the bend of the body, the direction of eye gaze—determines the sensory information available. How one should *move* one's body to pick up the task-relevant information, however, depends both on where that information is in the world and on the current, momentary position of the body. This means that internal attentional and selective mechanisms must be dynamically coupled to the body's current position and, further, must be continuously updated with shifts in bodily orientation and with movement (e.g., Georgopoulos, 1997; Presson & Montello, 1994; Schutte, Spencer, & Schöner, 2003; see also Smith, Thelen, Titzer, & McLin, 1999). Considerable evidence from a variety of domains indicates that this relation between the spatial orientation of the body and what we perceive is so central to our everyday experience that it can be reliably used by the cognitive system to solve other cognitive problems (e.g., Grant & Spivey, 2003; Richardson & Kirkham, 2004; Spivey, Tanenhaus, Eberhard, & Sedivy, 2002). In particular, contemporary theories of attention, object tracking, and working

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memory incorporate the spatial direction of attention as a key binding mechanism (e.g., Ballard, Hayhoe, Pook, & Rao, 1997; Humphreys & Riddoch, 2003; Treisman, 1998). In these accounts, the direction of bodily attention is crucial to how we internally link the constituents of cognition to each other—the redness of a red square to its squareness, the goal of a reach to the motor plan or of a speaker to an utterance.

Ballard et al. (1997; see also Lesperance & Levesque, 1995) specifically propose that *bodily manifestations of direction of attention* work as tags (or "deictic pointers") to keep track of objects in the world and also in memory. This idea can be illustrated through the robotics research of Roy (2005). In one study, Roy presented the robot with multiple objects, for example, a green apple left of center on a table and a red cup right of center on the table. The physical *spatial* reality of the robot and the objects means that when the robot orients leftward, the sensory system picks up information about the green apple, and when it orients to the right, the sensory system picks up information about the red cup. This relation between where the robot looks and what the robot "sees" is a physical fact that the cognitive system can use to generate considerable intelligent behavior. Over the course of the task, the *act of looking left* (within the current frame of reference) will repeatedly yield a view of the green apple and will also activate memories of what was just previously seen (or heard) when attending to that spot. This activation of recent memories *indexed* by the direction of attention enables the robot to detect changes in the physical layout and to connect experiences that are *about* the same object but separated in time.

Experimental analyses of human behavior in block construction tasks (Ballard et al., 1997), in object recognition tasks (Chun & Jiang, 2001; Treisman, 1998), and in memory retrieval tasks (Richardson & Kirkham, 2004) support the "tagging" and "binding" roles of bodily orientation. For example, in the "Hollywood Squares" experiments of Richardson and Spivey (2000), people were presented with four different videos, each from a distinct spatial location. Later, with no videos present, the subjects were asked about the content of those videos. Eye-tracking cameras recorded where people looked when answering these questions, and the results showed that they systematically looked in the direction where the relevant information had been previously presented. *Looking* in a certain direction is linked to memories of the information that had been in those locations.

Children learn words in the physical reality of looking, reaching, and acting on things in space, and thus the tagging and binding mechanisms provided by the spatial orientation of attention should be relevant to word learning. We investigated this proposal using a task first introduced by Baldwin (1993) and illustrated in figure 8.1 (Smith, Samuelson, & Spencer, 2006). The task is structured to capture some of the complexities of real-world word learning. Multiple objects are presented amidst shifts in attention and shifts in bodily action, and most critically, objects and their names are not experienced at the same moment in time. The experimenter sits

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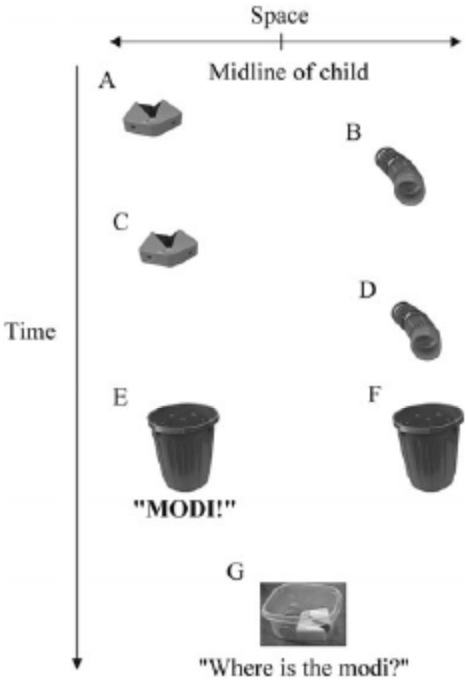

**Figure 8.1** Elements of the task used by Smith et al. (2006). The vertical axis is time in the task. See text for a description of the task. See color insert.

before a child at a table and presents the child first with one object at one location (figure 8.1A), so that, for example, the child must turn and reach to the left to retrieve the object. Then the experimenter presents the second object at a second location (figure 8.1B), for example, on the right. In this way, the task creates directional shifts in attention that are associated with each object. These objects are each presented again, each at the same location as before (figure 8.1C, D). Then, out of sight of the child, the two objects are then put into containers and the two containers (figure 8.1E, F) are placed on the table. The experimenter directs the child's attention to one container by looking into it (figure 8.1E) and saying, "I see a modi in here." The experimenter does not show the child the object in the container. Later the objects are retrieved from the containers, placed in a new container, and presented in a neutral location (figure 8.1G). The child is asked which one is a "modi." Notice that the name and the object were never jointly experienced, yet as Baldwin (1993) first demonstrated and as Smith et al. (2006) replicated, children as young as 15 months link the name to the appropriate referent.

A series of subsequent experiments indicate that young children (15–24 months old) solve this problem much like Roy's robot might, binding an object to its name through the body's momentary disposition in

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space. In particular, success in this task requires the consistent presentation of the objects in space *prior to the naming event*. The linking of different objects to different locations enables children—through their own bodily direction of attention—to connect the object experienced at one moment in time with the name experienced at another. Further experiments show that one does not need containers or hidden objects for children to succeed in this task. One can merely present the target object on the right and have children attend to and play with it there, and then present the distracter object on the left and have children attend to and play with it there. Then, with all objects removed—with only an empty and uniform table surface in view—one can direct children's attention to one side (by a gesture in the air to the right or left) while saying the name children will consistently and reliably link the name to the object associated with that direction of attention. Other experiments show that the *momentary bodily direction of attention* is critical to this mechanism. If the child's posture or position is shifted *after* the objects are linked to directions of attention but *before* the naming event, children cannot use their own bodily direction of attention as a "pointer" to the memory, and they fail to make the link.

Children's solution in the Baldwin task, using the direction of bodily attention to bind recent memories to current experience, is a simple one that works in defined spaces *because* of the physical reality of objects and bodies in space. It is an elegant solution that falls out of the fundamental fact that the body's momentary position in space is the immediate source of all new information into that cognitive system. In this way, the body is foundational to all learning.

## 8.2 EXAMPLE 2: COUPLING LIKE MINDS THROUGH LIKE BODIES

Research also suggests that the social context of word learning is essential to children's success (Baldwin & Baird, 2001; P. Bloom, 2000; Tomasello, 2000). This social context is very much about the body (Smith, 2000a, 2000b; C. Yu, Ballard, & Aslin, 2005). Direction of eye gaze, posture, and hand gestures all inform others of attentional state (e.g., Goldin-Meadow, 2003; Langton, Watt, & Bruce, 2000; Lee, Eskritt, Symons, & Muir, 1998). Recent developmental research shows that infants are highly attentive to these cues (e.g., Baldwin, 1993; Tomasello, 2000). In one study, for example, Baldwin and Moses (1996) showed that 13-month-old infants give special weight to the speaker's gaze when determining the referent of a novel label. Their experiments showed that infants established a stable link between the novel label and the target toy only when that label was uttered by an adult who concurrently directed her/his attention (as indexed by gaze) toward the target.

Smith (2000a, 2000b) and C. Yu et al. (2005) have argued for an analysis of social cues in terms of the dynamic coupling of the child's own bodily gestures to those of the social partner. This construal reveals the

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potentially profound insight that through their bodily actions, mature social partners might literally control the internal cognitive mechanisms of young learners. Quite simply, *where* young children look in the moment—how they turn their heads, their eyes, their bodies—will select and activate recent memories and bind them to the current input. And, where young children look is tightly tied to the *bodily* gestures—the eye gaze, head turn, hand movements—of the mature social partner. A mother's head turn and gesture to the right, for example, *causes* the child to look right, which causes the child to *see* a particular object or event and to *reactivate* memories recently associated with that bodily direction of attention. In this way, the social partner, through her own bodily actions, can control the internal cognitive machinery of the learner.

Smith, Richardson, and Schuller (2006) demonstrated the real-world relevance of these ideas. Mothers were asked to teach 14-month-old children the names of two novel objects. Both objects were continually available to the mother, and there were no constraints on how mothers distributed time between the two objects. During the 5-minute teaching/play period, mothers typically shifted their attention many times between the two objects, handing one and then the other to the child, demonstrating actions with one and then with the other, all the while naming them repeatedly. After this teaching and play period, the experimenter measured whether the child had learned the object names. She presented children (on a series of multiple test trials) with the objects and asked them to indicate the one named (e.g., "Where is the toma? Show me the toma"). The key result lies in the relation between children's learning of the object names and the mothers' *spatially directed behavior* with regard to the two objects during the teaching/play period. Children of mothers who spatially segregated the objects through their own bodily gestures—tending to hold one object with one hand (right) and the other object with other hand (left), putting one object to rest on one side and gesturing to, looking at, and naming that object when it was on its most habitually presented side—learned the name. Children of mothers who did not spatially segregate the two objects through their bodily actions were much less likely to correctly map the names to the objects.

Figure 8.2 shows a brief period of activity for two different parents—one (figure 8.2A) who spatially segregated the objects and whose child learned the object names, and one (figure 8.2B) who did not consistently segregate the objects in space and whose child did not learn the object names. Both parents moved the objects, actively engaged with them, and often named them. And indeed, from the perspective of a casual observer, both parents and children appeared highly engaged in the task. But when the first parent named one object, it tended to be in her left hand and on her left side, and when she named the second object, it tended to be in her right hand, on the right side. In contrast, when the second parent named the objects, they were in many different places and held by different hands. These differences mattered; an interaction pattern like the one depicted in the top

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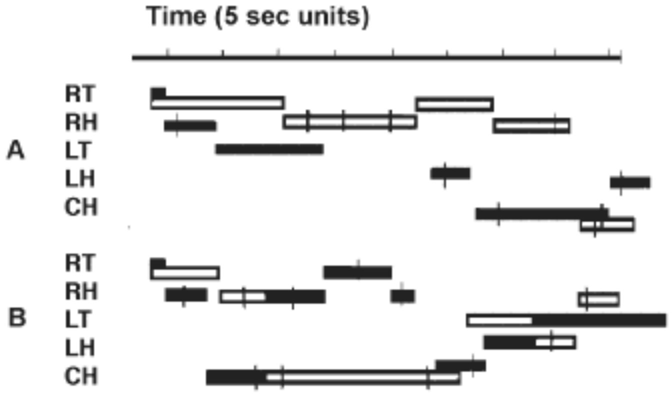

**Figure 8.2** Two parents' interactions with objects with their children. White bars, object A; black bars, object B. RT/LT, right and left side of table; RH/LH, right and left hand of parent; CH, child's hands (children tended to hold all objects with both hands). Lines indicate naming of the object by the parent.

panel of figure 8, where the two objects tended to be spatially segregated, was more characteristic of the experiences that led children to learn the two names than was the pattern shown in the bottom panel of figure 8. Why is the first kind of experience better for learning a link between a name and a thing? Because in the here-and-now of real-time learning, the child will encounter the same object multiple times, often acquiring only partial information about the object, its name, or its function in a single encounter. Moreover, these multiple encounters with a single object are naturally interspersed with attention to other objects and other events. In the ecology of real-time learning, the child must shift attention among objects as the discourse shifts and must coherently bind events relevant to one object that are experienced at different times (and not bind them to the wrong object). The embodied nature of attention helps solve this problem. Attention and learning in the moment are tied to learner's body and its disposition in space; moreover, the learner's body is coupled to the bodily gestures of the mature social partner.

Coupled minds in coupled bodies is arguably *the* most important force on human intelligence. Minds are in bodies with a particular morphological structure. Our body's momentary disposition in space reflects and feeds back on our internal cognitions. The body's momentary disposition in space is also a clue to others about the own internal states of the actor. Further, this one mind in this one body is in a world that contains other *similar* bodies, with similar morphological structures, coupled to *similar* minds. This couples our mind, our cognitive system, to the minds and cognitive systems of others.

The coupling of like bodies (and in this way like minds) is evident from earliest infancy (e.g., Cohn & Tronick, 1988; Rogoff, 1990; Schaffer, 1996;

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Trevarthen, 1988). Mothers' facial gestures and the sounds they make are tightly coupled to babies' behavior. When babies look into their mother's eyes, mothers look back and smile and offer a sound with rising pitch. When babies smile, mothers smile. When babies coo, mothers coo. These contingencies create a context for arousal and exploration and for learning how bodily gestures map to their effects in the world, and potentially for learning how one's own body maps to another's body. The physical and behavioral contingencies inherent in social interactions may provide the crucial structure for mapping like body parts to like body parts, and finally, these body mappings may yield inferences about other minds (see Smith & Breazeal, 2007).

Developing in a world of similarly structured minds coupled to similarly structured bodies in real time provides an additional level of higher order, multimodal correlations that may be responsible for notions of self, other, and intention (e.g., Leslie, Friedman, & German, 2004). Figure 8.3 illustrates how correlations emerging from coupled *like bodies* with *like internal cognitive systems* can create—through the body's external behaviors—ideas about the internal states of self and others. The key correlations are the correlations between the appearance of the self and the appearance of others (e.g., hands to hands, feet to feet), correlations between the behavior of the self and the behavior of others (looking to an object), correlations between one's own bodily behaviors and one's internal states (e.g., looking left and remembering what was on the left, maintaining the memory of a goal and looking in the direction of that goal), correlations between the external states of others and one's own internal states (where they look, where as a consequence one looks oneself, and thus what one sees and thinks about). The dynamic, socially embedded coupling of two intelligent systems—to each other through a similar body with similar body parts capable of doing similar things in the world—seems the likely origin of the very idea of mind.

In sum, our own body's orientation in space determines—moment to moment—what we experience and what we learn. Spatial direction of attention also serves as a pointing and tagging system for binding internal cognitive operations (including memories) to immediate experience. The outward manifestations of attention also provide others with information

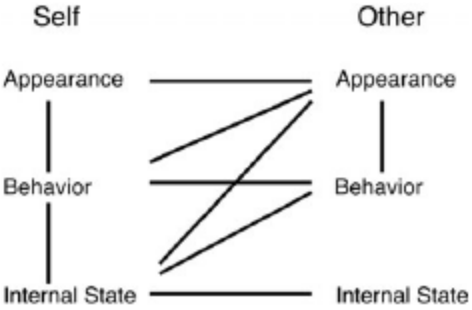

**Figure 8.3** Higher order correlations available to the self from the coupling of behavior with a social other.

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about our internal states, usable information that couples young learners to the internal states of mature social partners.

### 8.3 EXAMPLE 3: BODILY ACTIONS AND MEANINGS

Bodily actions make things happen in the world and, in so doing, create meaning. The body part most intimately involved in this meaning creation is the hands. As such, hands are near constants in children's visual fields as they learn about the world. Yoshida and Smith (2006) recently documented this by placing a small head camera with a wide-angle lens on 12- to 36-month-old children. Their goal was a description of the regularities in the visual field from the child's point of view. Analyses of these head-camera recordings suggest that *hands*—the child's or the mature social partner's—are in view in more than 80% of all frames, and this is so at every age. How might these hand actions—and the visual experience of them—create meaning?

Prior to word learning, the active manual exploration of objects provides infants with dynamically rich visual, proprioceptive, and haptic information about objects (Ruff & Lawson, 1990; Ruff & Rothbart, 1996). In one remarkably inventive experiment, Needham, Barrett, and Peterman (2002) fit 2- to 5-month-old infants with Velcro-covered "sticky mittens." These mittens enabled the infants (who were too young to reach for objects) to grab objects merely by swiping. Infants who were given 2 weeks of experiences with these mittens showed more sophisticated object exploration after these experiences *with the mittens off*. They looked at objects more, made more swipes at objects that were immediately preceded by visual contact, and produced more combined visual and oral exploration of objects than did control infants who had no exploratory experiences with "sticky mittens." Giving infants the ability to use their hands early enhances visual attention to objects.

Later in development, the integration of information from eyes and hands plays a formative role in category formation and in the selection and representation of visual properties. In one experiment, Smith (2005) presented children with the object shown in figure 8.4A. The children were told it was a "wug" and were then given the object to hold and shown how to it move up and down on a vertical path. The children then repeated this action three times. The experimental question was this: What other kinds of objects are also wugs? Children chose from new instances that were either elongated vertically or horizontally relative to the exemplar, as shown in figure 8.4B. Smith's conjecture was that children would be more likely to categorize the exemplar with the vertically rather than the horizontally extended alternative *because* of the experience of *manually* moving the object vertically. This conjecture is right, at least for 2- to 3-year-old children. Children who *acted* on an object by moving it up and down extended the name to vertically—but not horizontally—elongated objects. Children who

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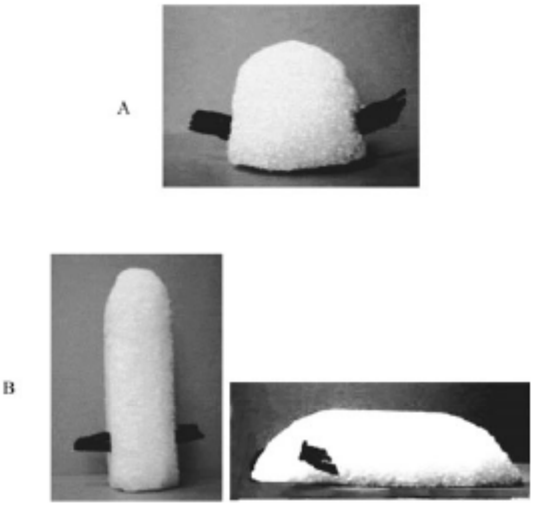

**Figure 8.4** The exemplar (*A*) and two choice objects (*B*) used in Smith (2005).

acted on an object by moving it horizontally back and forth extended the name to horizontally but not vertically elongated objects. Children who only watched the experimenter perform the action but did not do the actions themselves did not prefer test objects elongated in the direction of the watched action.

The same point was made in a second study, illustrated in figure 8.5, which confirmed a relation between symmetrical hand actions and the perceived symmetry of an object. In the experiment, children were shown the exemplar in figure 8.5A and told its name ("This is a zup") and then were shown an action with the object and were asked to perform this action. Half the children performed an action that involved holding the object in one hand by one part and moving it back and forth (figure 8.5B, right). Half the children performed an action in which the two sides were held in the two hands and rotated about a central axis (figure 8.5B, left). The children in the first case extended the name to new instances less symmetrical in shape than the exemplar (figure 8.5C, left). The children in the second case extended the name to new instances more symmetrical in shape than the exemplar (figure 8.5C, right). Again, children who only watched these actions performed by the experimenter but did not perform them themselves did not show the effect. The implications of these results are clear: how one holds, uses, and acts on objects determines the aspects of shape considered relevant to categorization and naming. These experiments show a potentially direct effect of manual action on perceived shape.

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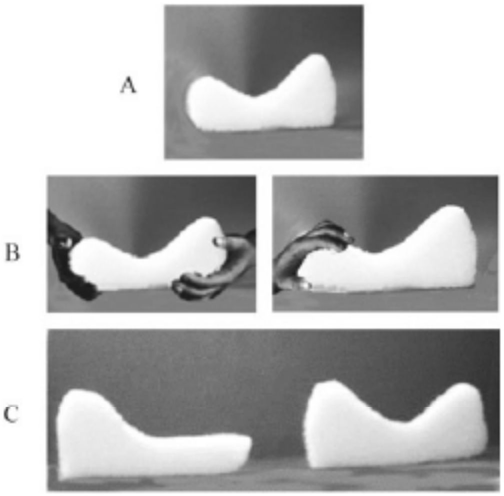

**Figure 8.5** The exemplar (*A*), actions (*B*), and two choice objects (*C*) used in Experiment 2 of Smith (2005).

The role of hand actions in organizing visual perception is not just a characteristic of the developmentally immature. In one adult study, Freyd (1983) showed an effect on drawing on the perception of letterlike figures. Freyd taught adults to recognize new letterlike characters by having them watch a letter being drawn. Subjects watched characters drawn by one of two drawing methods. Figure 8.6 illustrates a character and the two drawing methods. Although the drawing methods differed, the final static characters that resulted from the drawing in the two conditions were identical. After training with one drawing method, subjects were presented with static representations and asked whether they were instances of the modeled character. Some of these test characters were "sloppily" drawn versions

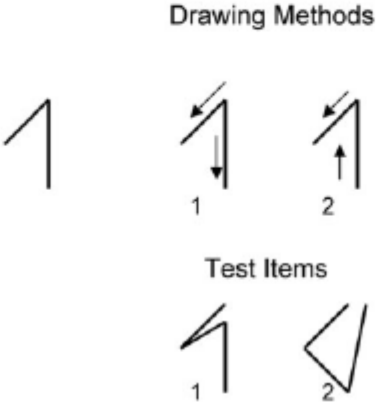

**Figure 8.6** Illustration of two drawing techniques and two test items used in the Freyd (1983) experiment.

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of the modeled character. Freyd found that subjects were reliably faster at recognizing static characters distorted in a manner consistent with the drawing method they observed during training than they were at recognizing equally distorted characters that were inconsistent with the observed drawing method. For example, subjects who observed drawing method 1 during training recognized test item 1 more rapidly than test item 2, whereas subjects who watched drawing method 2 recognized test item 2 more rapidly than test item 1. In brief, the static visual features that mattered for category membership were influenced by dynamic information about how those features were made in real time. Again, the coupling of vision and manual action yields visual percepts that are a blend, a joint product, of the multimodal experience.

In his theory of neural Darwinism, Edelman (1987) pointed to two principles of neural organization—degeneracy and reentrance—that are relevant to thinking about how coupled hands and eyes may create meaning and development. Neural degeneracy refers to how any single function may be carried out by more than one configuration of neural signals and to how different neural clusters often participate in a variety of different functions. Our multimodal sensory experience is a form of degeneracy. What we see and what we feel as we manually manipulate objects is a form of degeneracy—each modality is presenting overlapping and *partially* redundant information. This creates a potentially powerful source of learning whereby internal activity generated by one sensory (or motor) system may entrain the internal activity of another. Edelman calls this form of multimodal coupling *reentry*. Reentrance refers to the explicit interrelating of multiple simultaneous representations across modalities.

We can use these ideas to understand how action may inform visual perception in the action-shape and letter-writing experiments. For example, when a child held the "wug" and moved it up and down, the child generated a dynamic constellation of sensory experiences, including visual and proprioceptive. These multimodal experiences are time locked and correlated. Changes in the way the hand and arm feels as it moves the "zup" are time locked with activation produced in the visual stream by seeing the object move. The time-locked correlations potentially create a powerful learning mechanism, as illustrated in figure 8.7. The figure shows a physical object (the zup) and two modalities of interaction with the object.

One can describe these interactions in terms of a system of dynamic couplings. One coupling is between the physical properties of the zup as it moves and the neuronal activity in the visual system. Another coupling is between the physical properties of the zup and neuronal activity related to motor plans and felt movements. This coupling is bidirectional because the hand movements change the physical properties available to the sensory systems and because the activity in the sensory system is also a function of the momentary information presented by the object in its current position. The third and fourth couplings constitute what Edelman (1987) calls the reentrance: activity in the visual system is mapped to the motor system, and

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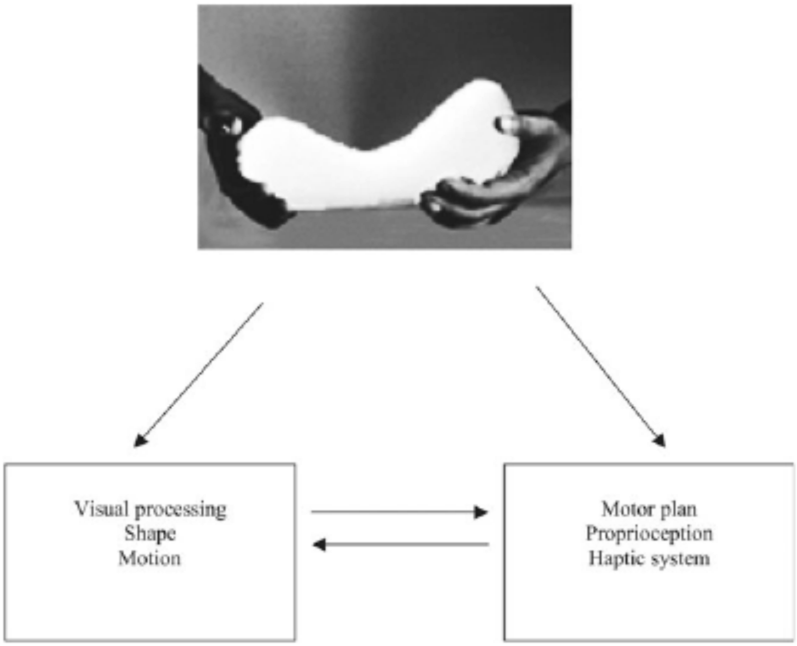

**Figure 8.7** Reentrant mappings between visual and haptic, proprioceptive, and motor planning processes.

activity in the motor system is mapped to the visual system. Thus, the two different sources of information—the sight and the feel of the action—are correlated in real time and directly influence and educate each other. At the same time, the visual system is activated by time-varying changes in shading and texture, and collinear movement of points of the zup and arm, the motor and proprioceptive systems are activated by time-locked changes in pressures, velocities, and heft. At every step in real time, the activities in each of these heterogeneous processes are mapped to each other, melding information from one system into the other.

The regularities emergent in the reentrant coordination of vision and action have the power to potentially yield higher order and more abstract concepts. One potential example of how this might work is suggested by Kemler-Nelson and colleagues' programmatic series of experiments on young children's attention to function in forming categories that also illustrates the potential power of hands and action in the formation of categories. In one study (Kemler-Nelson, Russell, Duke, & Jones, 2000), 2-year-old children were presented with novel complex objects with multiple parts like those shown in figure 8.8. One object, the exemplar, was named with a novel name. In addition, the children were shown a function that depended on one of those parts. For example, they were shown how the hinged shape could open,

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close, and latch. They then manipulated the part causing the box to open and close. After seeing and manipulating the hinge, the children were more likely to extend the object name to the test objects that also had hinged parts rather than to those that were similar in global shape but lacked the hinge. How the children acted on the objects—and the outcomes generated by their actions—seem likely to have organized their attention to some aspects of the visual information over others, potentially changing how object shape itself was perceived. Multimodal regularities emergent in the coupling of vision and manual action may, in this way, create such abstract meanings as "open." If so, then much meaning may reside in the hands—in their actions on objects and in the dynamic visual trajectories they create.

In sum, example 3 illustrates how the body's physical interaction with things in the world may *create* new forms of multimodal input that may carry and create meaning.

## 8.4 EXAMPLE 4: BODY PARTS AND EARLY VERB MEANINGS

Developmentalists have long noted that children's early verb meanings seem to be about children's own actions (e.g., P. Bloom, 2000; Huttenlocher, Smiley, & Charney, 1983). L. Bloom (2000) in particular has argued that children learn and use words because they are relevant to their

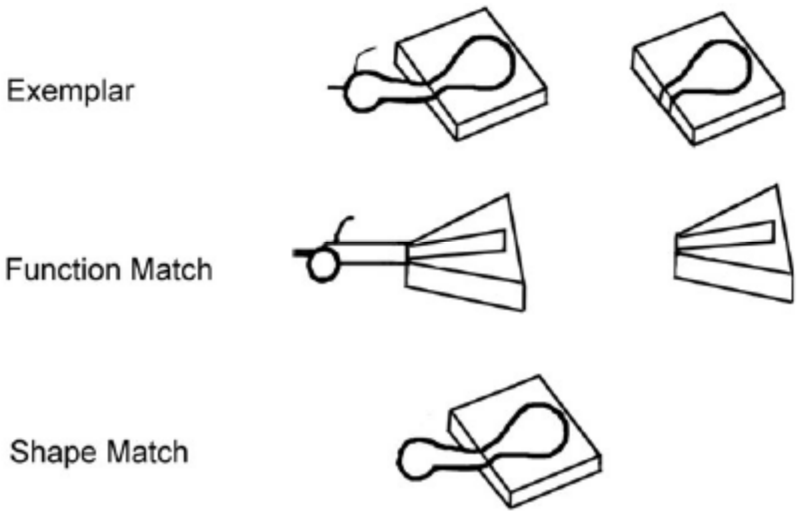

**Figure 8.8** Illustration of the objects used by Kemler-Nelson et al. (2000). Shown are the exemplar in its closed and open form, the function-matching test object that closes and opens, and the shape-matching test object than cannot be opened.

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own goals, desires, and actions. From this perspective, early verb meanings might be expected to be embedded in the child's bodily actions. Consistent with this idea is a landmark study by Huttenlocher et al. (1983) of young children's early comprehension and production of action words. These researchers found that young children were more likely to comprehend and produce words when they were about their own actions than about the actions of others. For example, children would say "kick" more frequently when they themselves were kicking than when they were watching someone else kick.

Self-action provides a richly interrelated set of immediate experiences out of which one might build meanings. As illustrated in figure 8.9, these include the agent's goal, the motor plan for a specific bodily action by a specific body part, the objects one acts on, as well as information about the effects of the action. Critically, it is the action *by a body part* that links these components, physically connecting goals to outcomes and realizing causes, effects, manners, and paths. Yet the role of the body in verb learning has rarely been considered.

As a first step in this direction, Maouene, Hidaka, and Smith (2006) asked adults how body parts link to the verbs that children learn early. We examined a corpus of 103 common English verbs that are normatively acquired by children by 36 months (Fenson et al., 1993). In a free association task, adults were asked to supply *one* body part associated with each verb. The participants were not told the reasoning behind the task and they were *not* asked for the body part associated with action; instead, participants were free to supply whatever body part popped into their heads for whatever reason. There were also no constraints on the scale of the body parts that might be offered: lips, gums, teeth, mouth, face, and so forth, were all possible associates. The rationale for this method was that if these verbs are associated with bodily actions done by particular body parts—and if this is

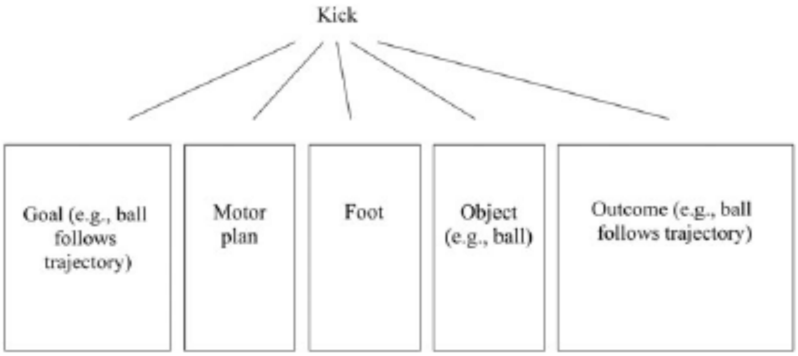

**Figure 8.9** Verbs are linked to momentary events that include goals, motor plans, body parts, objects, and outcomes.

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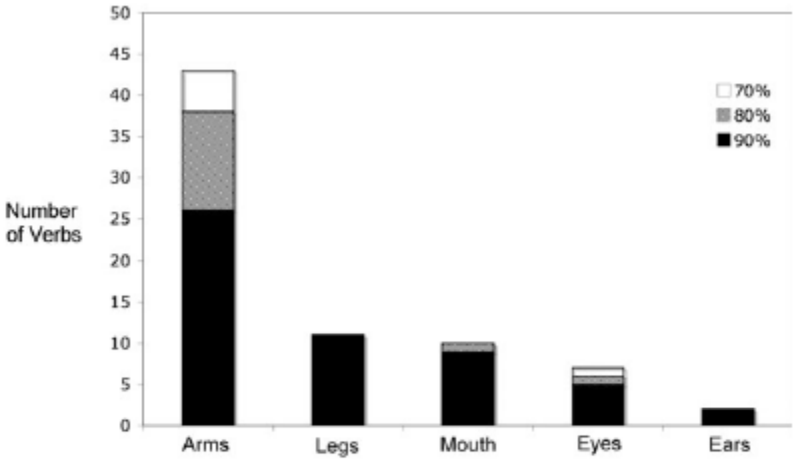

**Figure 8.10** Number of verbs (of 103) that are associated to five body regions by more than 70%, 80%, or 90% of adult judges.

shared knowledge by mature speakers of English—then adults should systematically associate specific body parts with specific verbs and should agree with each other.

The results suggest, first, that adults do associate specific body parts with these common verbs. They readily generated body parts (more than 62 unique parts at multiple levels of scale) but generally agreed with each other as to which parts were relevant to specific verbs. Figure 8.10 shows the number of verbs associated by 70%, 80%, and 90% of the participants with one of five regions: arms, legs, mouth, eyes, and ears. The explicit body parts included in these five regions are subparts of the regions region (e.g., the arm region includes arm, elbow, hand, fingers, knuckles). Fifty-three of the total 103 verbs, slightly more than half, were associated with the same body region by 90% or more of the respondents. Only a very few more verbs are added if those associated with region by 70% are included. In brief, slightly more than half these verbs are overwhelmingly associated with a single body region.

Further analyses examined the semantic structure of these verbs through a statistical procedure known as correspondence analysis (a kind of principal component analysis for qualitative data). These analyses seek to find a smaller number of dimensions than the original set (of 103 verbs by 62 unique body parts) that nonetheless captures most of the variance in the data set. The input to the analysis was a matrix of 103 verbs by 62 body parts. As shown in figure 8.11, the analysis yielded a three-dimensional space in which verbs (indicated as a point) were clustered into four groups; each of these groups had an elongated, almost linear shape, in the multidimensional space. Accordingly, we will call each of these four elongated

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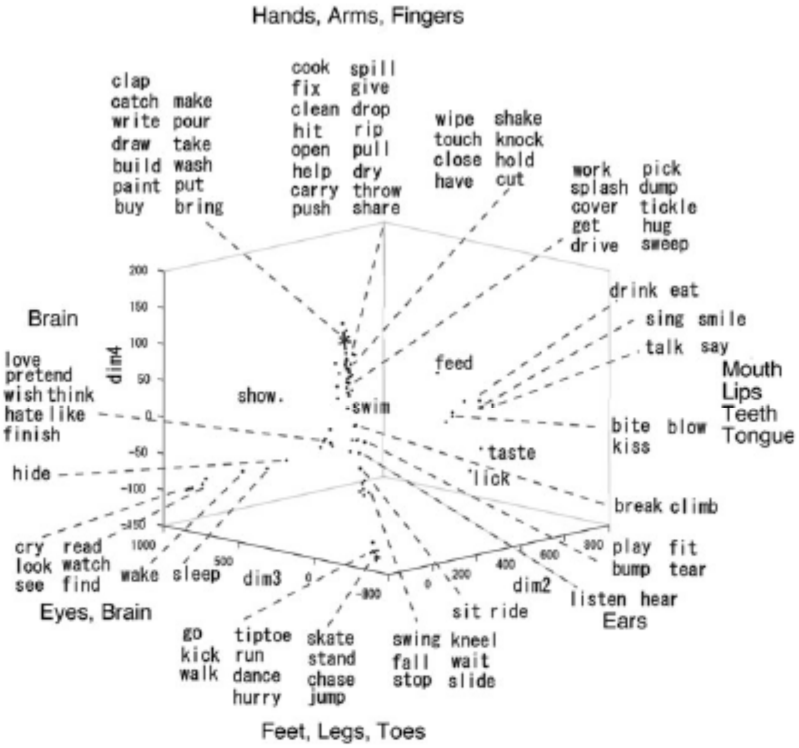

**Figure 8.11** The structure of the 103 verbs and their body part associations in three dimensions. (Dimension 1 of the CA analysis segregated the two ear verbs from all other verbs. For clarity of the figure, this plane is not shown.)

clusters of verbs "arms." The verbs at the outer *extremities* of each arm are the ones most exclusively associated with a single body part by subjects.

The most vertically aligned arm in the figure contains verbs associated with hands, fingers, and arms. These include verbs obviously involving the hands such as *clap* and *write* but also verbs such as *give*, *buy*, and *share*, verbs that might be considered to be more abstract and relational in their meaning but that elicited hand as the primary associated body part (with arm as the remaining named part; e.g., the proportion of named body parts that were hand + arm were 82%, 90%, and 80% for *give*, *buy*, and *share*, respectively). As one moves downward in this cluster, the verbs become less exclusively associated with hands and associated primarily with arms (e.g., 94% and 70% for *hug* and *sweep*) or fingers (e.g., *tickle*, 60% fingers, 20% hand) or with a mixture of body parts with hands comprising a significant proportion of the body parts named (e.g., *work*, 54% hands, with no other body part named by more than 10% of the respondents). In total, 53 of the

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103 verbs were associated by more than 50% of the adults with hands, arms, or fingers. Thirty-five were associated by more than 50% of the adults specifically with hands. In sum, many early verbs, including many with abstract relational meanings such as ***put***, are strongly associated actions by hands. This is perhaps not surprising in that hands are how human bodies generally make things happen and, in particular, how they connect goals to objects.

The verbs on the lower vertical arm are associated with legs. For example, ***stand***, ***jump***, ***chase***, and ***kneel*** were each associated by more than 96% of respondents with the legs (and leg parts, e.g., feet or thigh). But interestingly, ***hurry*** (65% legs, 32% feet) and ***go*** (54% legs, 40% feet) were also strongly associated with the legs. The verbs ***stop***, ***fall***, ***swing***, and ***wait*** fell in a middle cluster on this arm; each of these verbs was associated with the legs or feet by more than 50% of the participants but was also associated by other participants with the whole body and/or the torso. The verbs in the center—***play***, ***bump***, ***fit***, ***break***, and ***climb***—fall between the verbs unambiguously associated with the hands and those unambiguously associated with the legs; that is, these middle cluster verbs are ones that were associated with both hands and legs. In total, only 14 of the 103 verbs were associated by more than 50% of the participants with the legs (and their subparts of feet, thigh, toe, and knee).

On the right side of the figure are a cluster of verbs strongly associated with the mouth. All verbs in this cluster were associated with the mouth (lips, tongue, or teeth) by more than 80% of the participants. *Feed*, which is by itself, was associated with the mouth by 60% of participants and with hands by the other 40%. On the left side are two clusters of verbs associated with eyes. At the extreme are verbs such as ***cry***, ***look***, ***watch***, ***find***, and ***wake*** that show a range of responses from those that were strongly associated with eyes by 98% of respondents (***cry***, ***look***) to those verbs associated with eyes by 66% of respondents (***wake***). More internally on this arm are a cluster of verbs associated with both the eyes and the brain, mind, or head. These are the psychological verbs such as ***pretend***, ***wish***, ***think***, and ***hate***.

Overall, this correspondence analysis suggests that associations between the early-learned verbs and body parts are strong, coherent, and highly organized by four major bodily areas: the mouth, eyes (and also ears), legs and feet, and hands. Further, many of these individual verbs are systematically and strongly associated with a ***single*** area of the body. This result, although new and without precedent as far as we know, also makes sense. Most early verbs refer to physical actions by physical bodies and even those that do not, such as ***pretend***, ***wish***, ***think***, and ***hate***, lead to outward bodily behaviors that are visually perceptible and so associated with eyes.

Our further analyses suggest a relation among verbs, body parts and age of acquisition. We illustrate these relations in the body maps in figure 8.12. To generate these body-verb maps, a body-part meaning vector was created for each verb from the raw adult judgments. This vector represents

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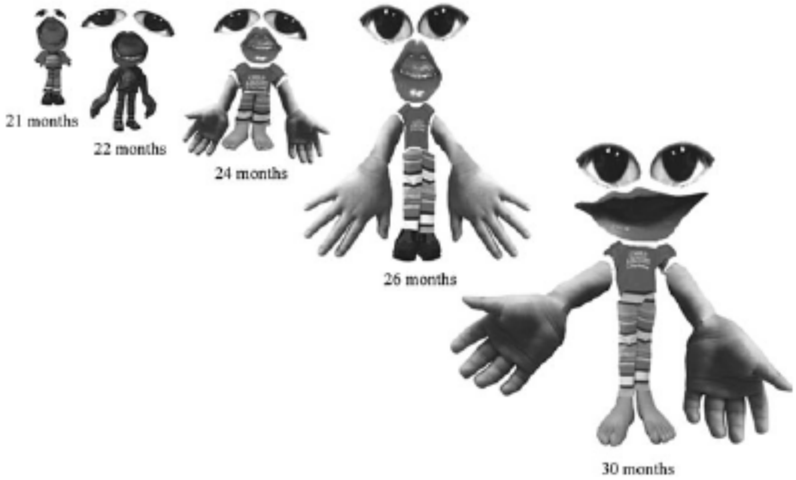

**Figure 8.12** Body maps of body parts associated with typically known verbs at five ages. The size of each figure illustrates the number of known verbs at each age; the area of each body part region indicates percentage of associations (across all verbs known at that age). See color insert.

the percentage of adult judgers who listed each body part as associated with the verb. Nested body parts (e.g., lip, mouth, head) were treated separately. For example, the "meaning" vector for *bite* has these values within it: 58 mouth, 38 teeth, 2 head, and 2 lip, because these are the percentages of adults who listed each as the single body part most associated with *bite*. We then summed the vectors for all the verbs acquired by a given age, for example, summing all the vectors of all verbs normatively produced at 22 month of age. These summary vectors were used to generate the body-verb maps in figure 8.12. The size of the homunculus grows with the number of verbs normatively acquired by that age, and the size of a constituent body part grows with the number of verbs associated with that body part. For these figures, age of acquisition was defined by the age at which 80% of the children in the normative study (Fenson et al., 1993) have this verb in their productive vocabulary.

The smallest verb-body map is for a normative 21-month-old, the starting point in our analysis. Normatively, children this age have nine verbs in their productive vocabulary. Body maps for four subsequent ages are also shown: 22 months (21 verbs), 24 months (45 verbs), 26 months (74 verbs), and 30 months (96 verbs). As is apparent, verb acquisitions are clustered by body part. At every age, children add new verbs related to all body parts, but different body parts dominate earlier versus later acquisitions. At 21 months, verbs involving actions of the mouth and lips dominate, accounting for 47% of the body parts associated with verbs known at this

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age. Over the next month, verbs pertaining to the face region including the eyes (22% of the body parts associated with the new verbs) are added, as well actions by the limbs (52% of the body parts associated with the new verbs). Growth in new verbs from 22 to 24 months overwhelmingly (86% of all new meanings) concerns actions by the limbs. The predominant region of growth after this point is in verbs associated with the hands, accounting for 58% of new additions from 24 to 26 months and 59% of all new additions from 26 to 30 months. At 30 months, verbs associated hands and arms dominate, accounting for 51% of all verbs in children's total productive vocabulary at 30 months. Together, these body maps provide a developmental picture of verb learning that is strongly organized by dominant interactions of body parts with the world.

The observed pattern of acquisition is not easily explained by the frequency of individual verbs in the learning environment. We directly examined the potential role of frequency by measuring the occurrence of the each of the 100 verbs in the CHILDES (Child Data Language Exchange) corpus of parent speech to children (MacWhinney, 2001). The frequency of the verbs in this large sample of parent speech is not correlated with their normative age of acquisition ($r = -0.11$, not significant). Saliency of the relevant actions also seems an unlikely explanation because there is no evidence that we know of to suggest that young children have a greater interest in kissing than tickling or in biting than hitting.

The clustering of verb acquisitions by body part does fit previous descriptions of lexical development suggesting that once children learn a few words in a given domain, the rate of growth of new words in that same domain accelerates rapidly (Pollmann, 2003; Samuelson, 2002; Sandhofer & Smith, 1999; Yoshida & Smith, 2001). This pattern has been observed for object, color, number, and animal words. It appears that as children learn individual words, they also learn the more general parameters of meaning that distinguish words in that domain. Applying this idea to the present data suggests that *the body parts involved in the actions* define like kinds of verbs. There are a number of potential dimensions of meaning that are related to the body part region, including proximity of action to the body, the extent of the space in which the action may take place, and the variability of movements, as well as the objects involved.

There are strong associations between early-learned verbs and body parts. The strength, coherence, and apparent relation to acquisition of these associations fit the embodied reality of children's learning: children learn verbs as they move and act in the world. Not surprisingly, then, the body pervades representational systems.

## 8.5 BEYOND THE BODY: EXPANDING SPACES AND MEANING

Traditional theories of cognition segregate the mind from the body, from perception, and from action. Sensory systems are seen only as input devices

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and motor systems as output devices. There are grounds to reject outright this conceptualization of the cognitive system (see, e.g., Barsalou, 2003; Clark, 1997; Thelen & Smith, 1994); however, even within this traditional conceptualization, it seems highly likely that the body and its structure would leave its mark on internal cognitive processes and representations. Our own body—how it moves, the location of its parts and sensors, how those parts interact with the physical world and create change in the physical world—is the most pervasive regularity in experience. This very fact, however, makes it likely that mind (and brain) is not sequestered and not separate in mechanisms and processes from those of the body. The physical reality of the body in a physical world provides the cognitive system with mechanistic links to the world it can count on. The examples reviewed in this chapter, all focusing on how children learn words, suggest that these mechanistic links are crucial to attention, to solving the binding problem, and to understanding one's own mind and those of others, as well as to the discovery of meaning in the world and its representation.

In summary, then, understanding developmental process requires taking the physical reality of the body seriously. The body through its different sensory systems provides the developing organism with separate streams of information about the world, about the self, and about others—from hands, eyes, ears, and so forth. The multiple overlapping and time-locked sensory systems enable the developing system to educate itself—without defined external tasks or teachers—just by perceiving and acting in the world. Babies are physical beings in a physical world. Their own physical reality creates regularities (e.g., between how they move their hands and what they see, and between where they look and what they see). The physical world also offers on its own rich regularities that organize perception, action, and ultimately thought. The intelligence of babies not only resides inside them but also is distributed across their interactions and experiences in the physical world. Bodily action—in a moment, in a physical world—is what integrates different internal processes, is what couples the developing infant to social others—and in so doing may be crucial to the creation of higher order mental functions.

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