Cognitive Science 32 (2008) 1200–1216

ISSN: 0364-0213 print / 1551-6709 online
DOI: 10.1080/03640210802019997

Body Parts and Early-Learned Verbs

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Received 25 May 2007; accepted 11 February 2008; received in revised form 16 November 2007

Abstract

This article reports the structure of associations among 101 common verbs and body parts. The verbs are those typically learned by children learning English prior to 3 years of age. In a free association task, 50 adults were asked to provide the single body part that came to mind when they thought of each verb. Analyses reveal highly systematic and structured patterns of associations that are also related to the normative age of acquisition of the verbs showing a progression from verbs associated with actions by the mouth, to verbs strongly associated with actions by hand and arm, to verbs not so strongly associated with any one body part. The results have implications for proposals about embodied verb meaning and also for processes of early verb learning.

Keywords: World learning; Language; Verb meaning; Embodiment

1. Introduction

The body stands between the mind and the world and thus the properties of the body itself may shape knowledge. This embodiment hypothesis has attracted recent interest in the study of common verbs.

Many common verbs—for example, *kiss, hug, kick*—seem to be about actions performed by specific body parts. Further, imaging studies show that merely hearing a verb (e.g., *kick*) activates the cortical motor areas relevant to moving the appropriate body part (e.g., leg and foot; see Hauk, Johnsrude, & Pulvermüller, 2004; also see Boulenger et al., 2006; Pulvermüller, 2005). Behavioral studies also suggest a connection between verbs and movements by particular parts of the body. For example, moving the arm away from the body slows judgment about the sentence, "Open the drawer" (an action involving the movement of the arm toward the body (Glenberg & Kaschak, 2002). Such results suggest that the on-line processing of verb meanings may involve or interact with some of the same processes that generate bodily

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action (Barsalou, 2003). These past studies, by their very nature, examined only a small set of select verbs. An understanding of how generally verbs relate to bodily action may benefit from a broader examination of their associations to specific body parts.

This article is a descriptive study of the body-part associations of 101 common English early-learned verbs. These verbs comprise the starting point for the English verbal system. Moreover, young children first comprehend individual verbs in the context of their own action rather than in the context of the actions of others (Huttenlocher, Smiley, & Chaney, 1983; but, see Childers & Tomasello, 2006), an observation that suggests that first-learned verbs may be strongly linked to action and thus the parts of bodies that perform those actions. Using a free-association task, the experiment asked adults to supply one body part for each verb. If these verbs are associated with specific body parts—and if this is shared knowledge by mature speakers of English—then adults should systematically associate specific body parts with specific verbs, and they should agree with each other.

The analyses examined the structure of these associations with respect to two questions: (a) Are body-part associations pervasive and systematic in this corpus of early learned verbs?, and (b) Is the age of acquisition of a verb related to its associated body parts? The goals of this study are purely descriptive; an understanding of the extent and nature of these possible associations would seem prerequisite to determining their semantic significance.

2. Method

2.1. Participants

In the main experiment, the participants were 50 college undergraduates—half male and half female. In a supplementary control experiment, 30 college undergraduates, half male and half female, participated.

2.2. Stimuli

The verbs, given in the Appendix, were 101 action terms from the Bates–MacArthur Communicative Developmental Inventory for American English (MCDI; Fenson, Dale, Reznick, & Bates, 1994). This inventory includes the verbs that are normatively in the productive vocabulary of at least 50% of children learning American English by 30 months of age. Two verbs, *tear* and *stay,* on the inventory were not included; *tear* because it is a homonym with two distinct meanings (ripping and crying) and *stay* by experimenter error.

2.3. Procedure

Participants were tested individually. Each was given a randomly ordered list of the 101 verbs and asked to supply the *one* body part that first came to mind when they thought of each verb. There were no constraints and no suggestion that participants think of the actions. Participants were free to supply any body part, at any level of scale (e.g., fingernails, fingers, hands, arms, whole body).

3. Results

Sixty-one uniquely different body-part words were offered by the participants. In this count, singular and plural forms of the same noun (e.g., *hand* vs. *hands*) are considered to be the same word; and, in the following, all references to the actual body-part words provided by the participants are capitalized. Figs. 1a and 1b provides a matrix of the 101 verbs by the 15 most frequent body part words. By inspection alone, there is considerable agreement among adults as to the body parts relevant to a specific verb, with some verbs strongly associated, for example, to legs or leg parts; others to arms and hands. We examine the structure of these associations in three sets of analyses: (a) an examination of the similarity relations among the verbs in terms of their body part associations, (b) an examination of the localization of the verbs with respect to body regions, and (c) an analysis of the normative age of acquisition of the verbs in relation to their localization.

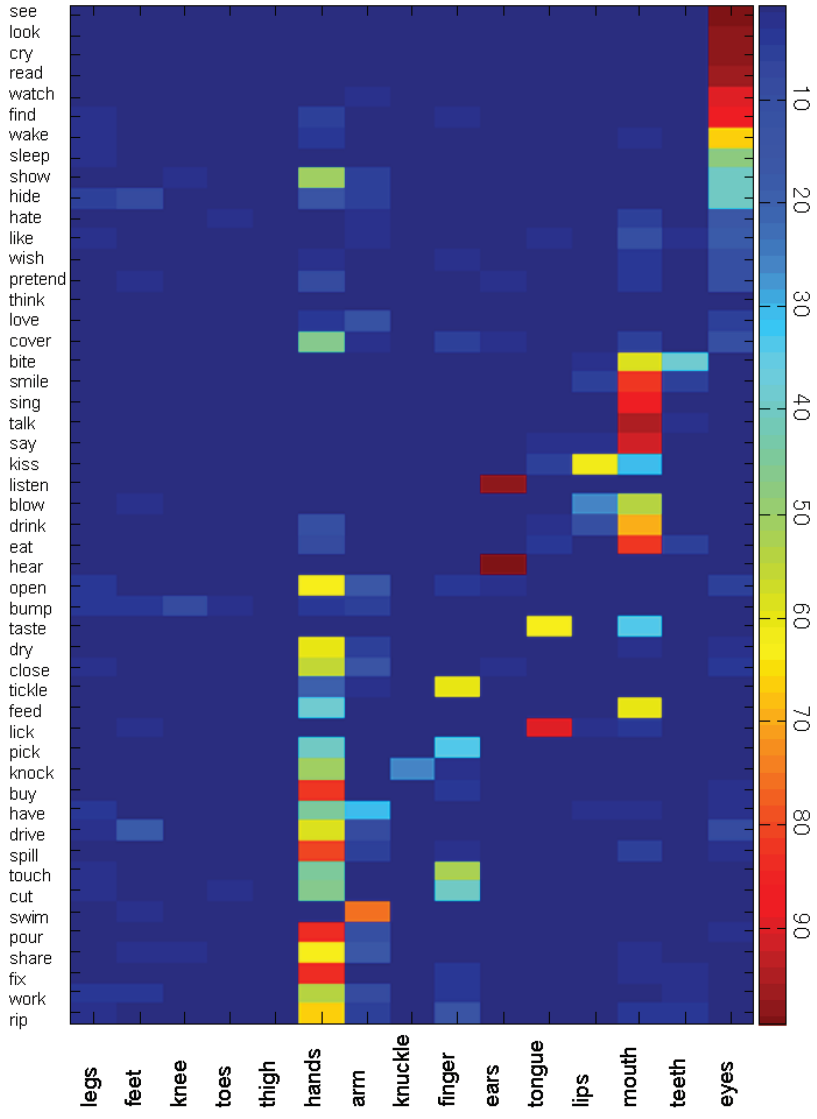
3.1. Similarity relations

To examine the similarity of the verbs to each other with respect to their body part associations, we submitted the matrix of associations (101 verbs by 61 body parts, available at http://www.indiana.edu/∼cogdev/labwork/online-annex.html) to a correspondence analysis (CA). Like principal components analysis and other dimension reduction techniques, the goal of CA (which is appropriate to discrete data) is to reduce the data in a high-dimensional data set into a lower dimensional description while maintaining the variance structure (the similarities and differences) among the individual instances. In this way, one can discover the "dimensions" that "account" for most of the similarity structure among instances. Dimension reduction techniques, such as CA, serve the purpose of discovering and describing structure.

In the present case, the first four dimensions, the dimensions that account for 34.7% of the variance among the judgments, present a highly coherent picture. The first dimension partitioned two verbs (*hear, listen*)—each associated by 100% of the participants with ears—from all other verbs. The similarities among the remaining verbs on the next three dimensions are illustrated in Fig. 2, and an animation of the figure (rotation of the 3D space) is available at http://www.indiana.edu/∼cogdev/labwork/online-annex.html. For present purposes, what is important in this figure is the degree of structure and fact that the verbs fall into four distinct clusters, with verbs in the same cluster having similar body part associations and those in different clusters having different patterns of associations.

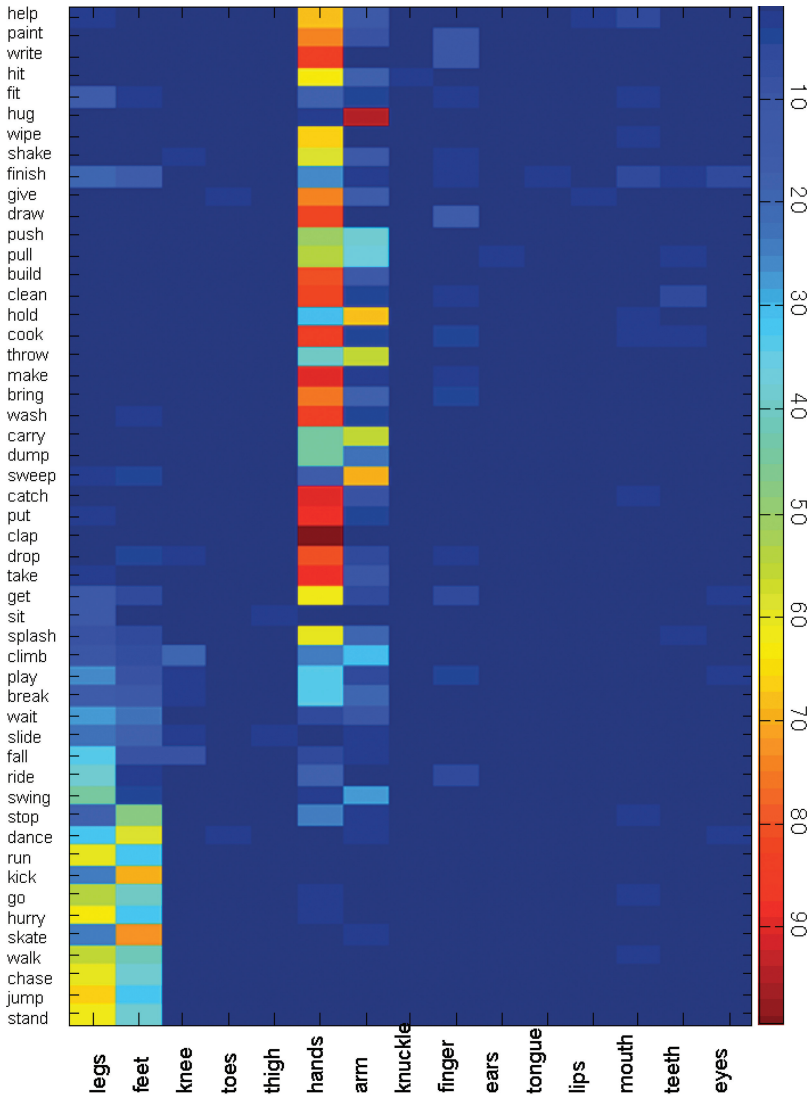
To make the structure revealed by the CA more intuitive, we describe some of the verbs and body part associations associated with each cluster. The top-most cluster contains verbs associated with the specific labels of HAND, FINGER, and ARM. Verbs higher in the cluster were strongly associated by more participants with the word HAND and those more in the middle of this cluster were more frequently associated to the word ARM. Lower in this cluster are verbs (e.g., *drive, sweep*) associated with HAND or ARM but also with a variety of other body parts. In total, 52 of the 101 verbs fall in this cluster. Verbs associated with LEG and FEET are in the cluster at the bottom of the figure, with the lowest verbs (e.g., *stand, chase)* most strongly associated with component of legs, and those toward the center (e.g., *play, fit)* associated by some with HAND and by others with LEG or FEET. The right-most cluster

consists of verbs strongly associated with the mouth and its parts Finally, on the left side are verbs associated with EYES, with those at the extreme left strongly associated with, by all respondents, EYES (e.g., *cry, watch, find*) and those nearer the center associated with EYES by some respondents but with BRAIN and MIND by others (*pretend, wish, think, hate*).



(a)

Fig. 1. (a and b): The degree of association of the 101 verbs to 15 frequent body-part labels. *Note:* Verbs are ordered on the *y* axis, and body parts are ordered on the *x* axis so as to cluster verbs with similar associative patterns. Strength of association (the percentage of participants offering a particular body-part label) is indicated by the color of the region. *(Continued)*



(b)

Fig. 1. (Continued)

Overall, the CA indicates that adult speakers share coherent and structured knowledge about body parts and common verbs.

The largest group of verbs, the hand and arm verbs at the top of Fig. 2, show additional finer-grained structure. This was revealed in a second CA analysis that examined just the 59 verbs for which any participant offered any part of the hand or arm as an associate. Fig. 3 shows that these verbs organize into four subgroups (on the two dimensions that account for the most variance; 28%): verbs associated with (a) HAND and ARM, (b) FINGER and HAND, (c) HAND and LEG, and (d) primarily with HAND alone. These body part associations thus

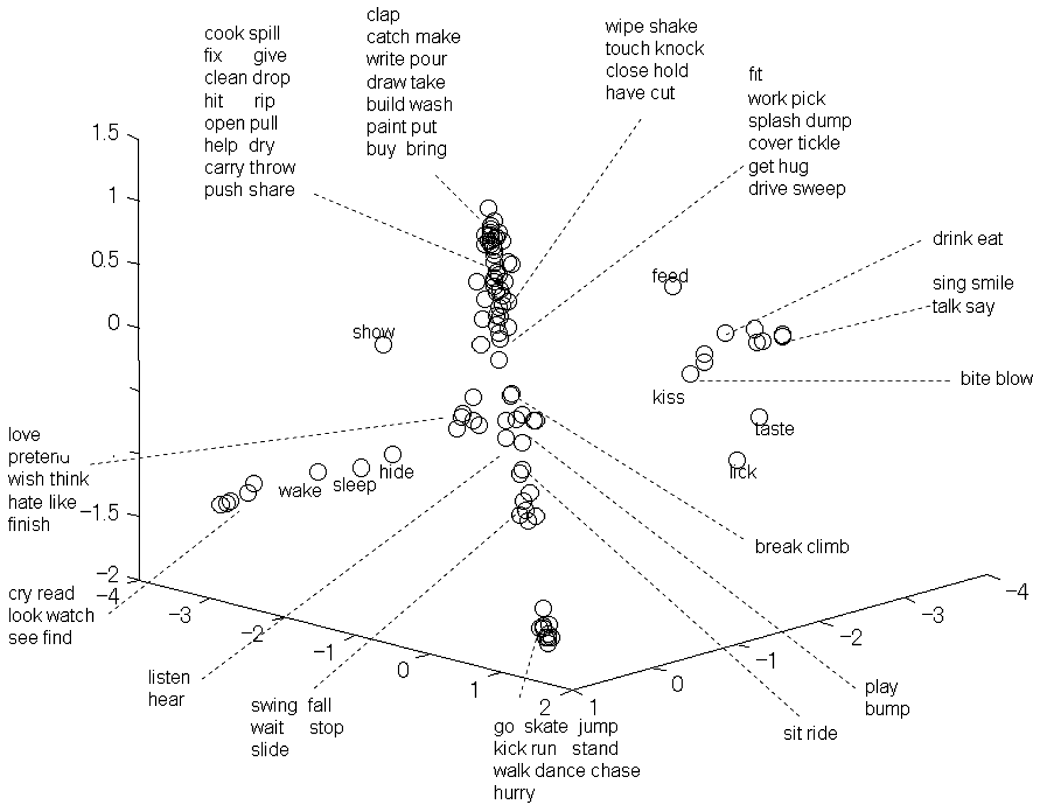


Fig. 2. The coordinate space derived from the correspondence analysis. *Note:* The scores along each dimension are standard deviations (see text for clarification).

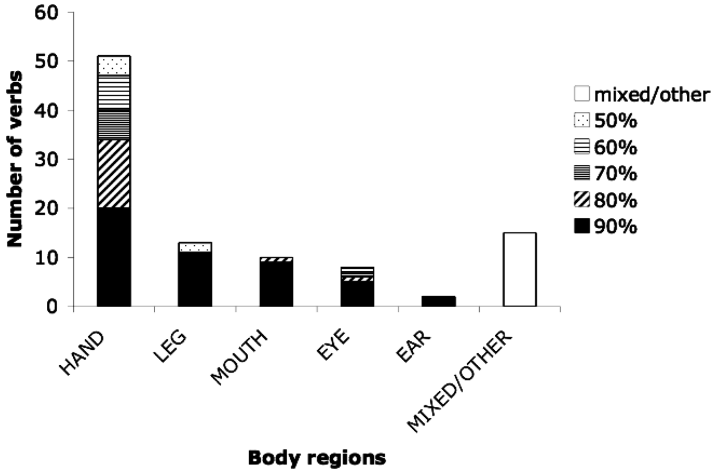


Fig. 3. Number of verbs associated by at least 50%, 60%, 70%, 80%, or 90% of participants with the body regions defined in Table 1. *Note:* Shown (in white) are the verbs that do not meet this 50% criterion of association.

appear to reflect knowledge of specific kinds of movements—the finer grained movements of fingers and hands in picking or tickling, for example, versus the larger whole arm movements of hugging and throwing.

One notable aspect of the results of both CA analyses is that the verbs consistently associated with specific body parts include both highly concrete verbs that clearly label actions by specific body parts (*kiss, kick*) but also verbs often considered to be "light" such as *put, buy, give, open, help, get,* and *go.* By some accounts, these verbs have minimal semantic content of their own but gain their relational meaning through their argument structure and use with other words (e.g., see Gleitman, 1990). That may well be the case, but the participants in the present experiment nonetheless connected these verbs to body parts. In sum, association to a body part characteristic of the action as it happens in the physical world is not just the property of a select few verbs but appears to be a property of many common and early-learned verbs.

3.2. Localization

Although the participants offered a total of 61 unique labels, just 15 unique terms accounted for over 84% of the associations. These 15 terms correspond to the five discrete body regions listed in Table 1. In a second analysis, we used just these 15 body-part terms to determine the degree to which participants localized individual verbs into five body regions. Fig. 3 shows the number of verbs associated with each of these body-part regions by increasing percentages of participants (from 50%–90%). What is noteworthy in this figure is the extent of agreement among participants that individual verbs are linked to specific body regions. Only 15 verbs were not systematically associated with a single body region (the same verbs that lie toward the center of Fig. 4): *love, swing, slide, play, pretend, sleep, wish, hide, think, ride, bump, hate, finish, like,* and *fit*. From inspection of the specific body part associations, these 15 verbs fall into two broad classes: (a) verbs involving the whole body that were associated to multiple body regions and (b) psychological or state verbs that were sometimes associated with EYES but also with internal body parts (BRAIN, MIND). Overall, this analysis supports the CA by showing the pervasiveness of strong associations between most individual verbs and one body region. In general, adult speakers localize common verbs, including light and relational ones such as *give, get,* and *go,* to specific body regions.

Table 1
The 15 body-part labels offered by participants that account for 84% of all associations and their five body regions

Region	Body-Part Labels
mouth	MOUTH, TONGUE, LIP, TEETH
eye	EYE
ear	EAR
hand	HAND, ARM, FINGER, KNUCKLE
leg	LEG, FEET, KNEE, THIGH, TOE

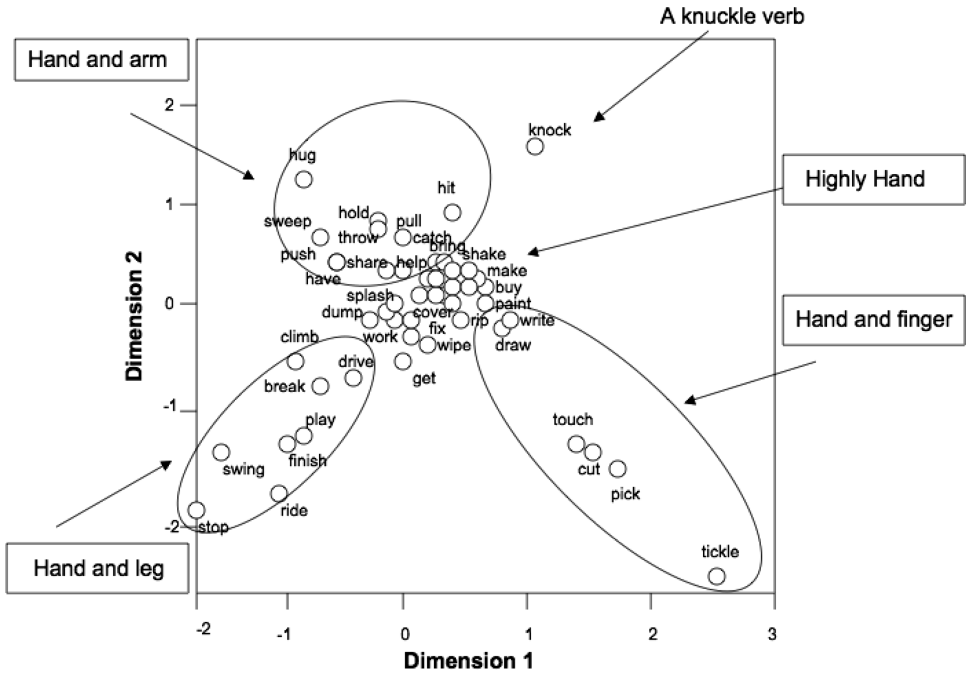


Fig. 4. The similarity relations among 59 verbs to which at least some participants associated hand, arm, or their parts on two dimensions as revealed by a second correspondence analysis. *Note:* The scores along each dimension are standard deviations.

3.3. Age of acquisition

The age of acquisition for each verb, determined from the MCDI norms, was defined as the youngest age at which 50% of the normative sample was reported to have the verb in their productive vocabulary (Fenson et al., 1994). Verbs were grouped by monthly age of acquisition—from 21 months to 28 months or later (with 24 and 25 months combined because only 5 verbs are normatively acquired at 24 months). Verbs were also partitioned into three groups according to the percentage of participants who associated the verb with one body region (as defined in Table 1): (a) very strongly localized—over 90%, (b) localized—between 50 to 89%, and (c) not localized—fewer than 49% of participants.

Fig. 5 shows the number of verbs that exhibited each of the three degrees of localization as a function of age of acquisition. At all ages, as in the corpus as a whole, most verbs are localized with respect to body part regions. Nonetheless, comparisons of adjacent age groupings suggest several transition points. Between 21 and 22 months, there is a reliable difference in the rank order of verbs by their strength of association to one body-part region: Mann–Whitney $U(9, 12) = 27$, $p < .05$. All but one verb acquired by 21 months of age was strongly localized. This suggests that verbs that label actions strongly linked to just one part of the body may be particularly salient or easy to acquire. A second transition is suggested between 22 and 23 months. Beginning at 23 months and lasting through to 27 months is an extended period in which many verbs are acquired and in which most of these verbs

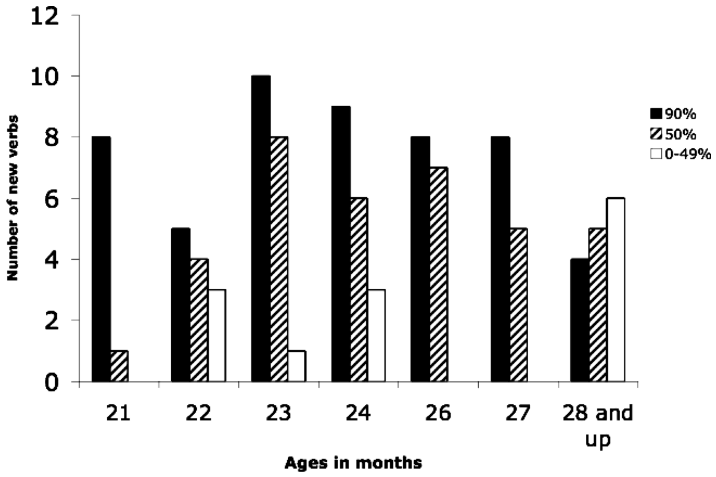


Fig. 5. Numbers of verbs at seven ages of acquisition that were associated by fewer than 50% of participants, by at least 50% of participants, or by at least 90% of participants with the five body regions defined in Table 1.

are localized. However, relatively many of the verbs acquired at or after 28 months are not localized in their associations: Mann–Whitney $U(13, 14) = 53$, $p < .05$. This fact suggests the possible later entry of verbs not tied to localized action. This finding fits with previous research indicating that, in general, verbs with more concrete meanings are learned earlier than ones with more abstract meanings (e.g., Bloom, 1991; Gentner & Boroditsky, 2001; Tardif & Wellman, 2000; Hirsh-Pasek & Golinkoff, 2006). These results also hint at two other important players in development: (a) Concreteness might be linked to action localized to a specific body region, and (b) complexity (of the body parts involved in the action) could play a role in acquisition.

Fig. 6 shows the number of verbs in each age of acquisition grouping that were associated with the five body regions. At 21 months, children have learned verbs associated with several different body regions, but the most prevalent regions are leg and mouth. Between 22 and 27 months, verbs associated with the hand and arm region dominate. The latest learned verbs in this corpus appear to be the most different as they include the psychological and state verbs that are not strongly localized with respect to the five body regions.

As a global measure of the relation between body parts and age of acquisition, we calculated the correlation between the means of the distance of any two verbs in their body-part associations and their distance in age of acquisition. Each verb was defined by two vectors: the 61 unit body-part vector of the verb and also a 15 unit age-of-acquisition vector that consisted of the proportion of children in the normative sample who had the verb in their productive vocabulary at monthly intervals from 16 to 30 months (Fenson et al., 1994). Using these data, we calculated the city-block distance of every verb's body-part vector to every other verb's body-part vector, and the city-block distance of every verb's age-of-acquisition vector to every other verb's age-of- acquisition vector. The correlation between the means of the body-part distance and the age-of-acquisition distance was .692 ($p < .001$), indicating that verbs that have similar body part associations have similar acquisition patterns. Because there

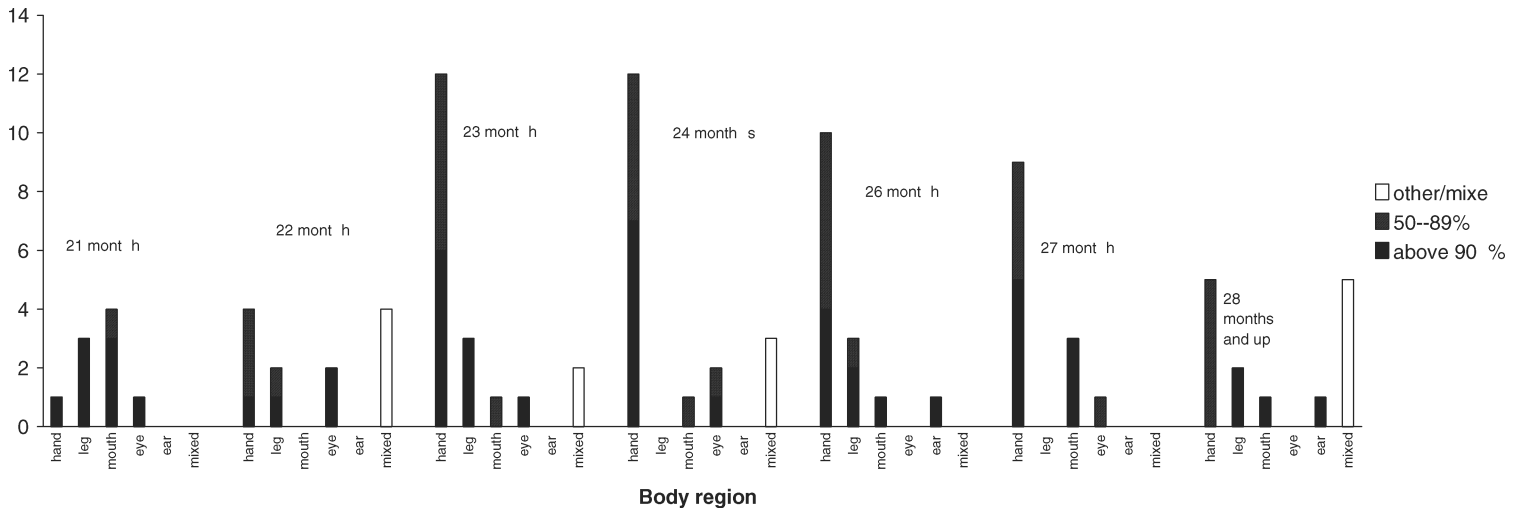


Fig. 6. Numbers of verbs associated with each of five body regions by at least 50% or at least 90% of participants, or not associated with any one region as a function of age of acquisition.

Fig. 7. Body maps of cumulative verbs in productive vocabulary at 21, 23, and 27 months. *Note:* Size of figure represents number of verbs; size of body part represents aggregate number of body part associations to the known verbs at that age grouping.

are necessarily dependencies among the distance scores in this analysis (the body part distance between Verbs A and C is not independent of that between Verbs B and C), we sampled 50 independent pairs from all possible pairs and calculated the distribution over 1,000 different samplings. The mean correlation calculated from these samplings is 0.678 (95% confidential interval, 0.602–0.750). Again, verbs with similar body part associations tend to have similar acquisition patterns.

Fig. 7 provides a pictorial summary of the results—body part maps of the cumulative verb vocabulary of children at three age levels. The size of each "homunculus" indicates the total number of verbs normatively in the productive vocabulary of children at the indicated age. The size of a constituent body part grows with the number of times that body part was associated to verbs known at that age level. These maps illustrate the strong association of early-learned verbs with body parts, the early acquisition of mouth and leg verbs and subsequent growth of eye and hand verbs, and the overall dominance among these 101 early-learned verbs of associations to hands and arms.

3.3.1. Control study

Our procedure asked participants to provide body part associations for verbs and so they did with those associations showing much agreement among participants and also considerable internal structure. The degree of consistency and structure suggests that these associations reflect knowledge that people have—and thus may potentially use—in their understanding of common verbs and the actions they label. However, it is possible to argue that the method of asking for associations of a set kind was guaranteed to find consistency and structure whether those properties actually existed in people's knowledge of verbs or not. Accordingly, to check on this possibility we tested an additional group of 30 participants in the very same procedure, except that we asked them to supply us with the first location that popped into mind when they heard the verb. We chose locations for the control task because

actions always take place somewhere just as they always involve the body, and because it seemed possible that many common actions might be associated with common locations (e.g., kitchen, bath). Thus, if the free-association task—rather than the specific importance of body parts to people's knowledge of verbs—determined our pattern of results, we might expect to find a structured pattern for locations.

The results from this control study show that the task itself does not create structure where there is none. There was little pattern or consistency among the locations generated in the association task for individual verbs. First, whereas 50 participants in the main experiment generated just 61 unique body parts, just 30 participants in the control experiment generated 824 unique locations. Further, these locations are not easily grouped (e.g., just 26% are the rooms within a house). Thus, whereas just 15 unique body parts account for 84% of body part associations, the 15 most frequent locations account for only 36% of the location associations. Further, no individual verb exhibited a strong association with any location. For example, *sleep* was associated with 28 different unique locations including work, home, bed, car, and hospital; *eat* was associated with 27 unique locations including kitchen, school, car, ice cream shop, game. Whereas the average number of unique body parts offered per verb was 6.3, the average number of unique locations offered per verb was 26. Thus, these results suggest that, although body parts may not be unique in their relation to verbs, they appear special, at least relative to locations. Moreover, the control results show that the task itself does not create structured associations.

This is not to say that the present method is without limitations; participants were asked to supply body part terms, and the fact that they did so need not mean that these associations play a significant role in verb semantics. There are at least two counter arguments as to why these associations are likely, nonetheless, to be relevant to the cognitive processes that support verb comprehension and learning. First is the robust and coherent structure of the associations themselves. Second is the relation of these associations—generated by adults—to an also orderly acquisition pattern. Both aspects of the data suggest shared, consistent, and structured knowledge about how verbs relate to bodily action.

4. General discussion

In philosophy (Lakoff & Johnson, 1999), cognitive science (Dourish, 2001), artificial intelligence (Anderson, 2003), and psychology (Barsalou, 2003; Wilson, 2002), there has been increasing discussion as to whether cognition may only be understood in its relation to the physicality of the body and its real-time activity in a physical world. This idea is sometimes characterized as the *embodiment* hypothesis. As three excellent recent reviews of this hypothesis make clear (Anderson, 2003; Wilson, 2002; Ziemke, 2001), embodiment is used to capture a variety of quite different notions with respect to the meaning and representation—including the idea that even abstract concepts are influenced by and show signature effects of perception–action (e.g., Landy & Goldstone, 2007); that abstract concepts are often understood via metaphor to more grounded, concrete, and physical meanings (e.g., Matlock, 2004); and, more radically, that the underlying processes in which meanings

are represented are fundamentally sensory-motor in nature (see Barsalou, 2003). All these possibilities are consistent with—and none is singled out by—the present data.

Pertinent to these issues, linguists and cognitive anthropologists have long recognized the importance of body parts as a grounding metaphor in many abstract semantic domains, including number, space, and emotion (de León, 1994; Saxe, 1981; Yu, 2004). Although we know of no suggestion that body parts play such a metaphoric role in verb meaning, the present evidence may provide a starting point for such analyses (but, see Richardson, Spivey, Barsalou, & MacRae, 2003). Contemporary studies in cognitive neuroscience suggest that at least some verbs automatically activate the sensory-motor regions that represent the specific body parts involved in performing the action (e.g., Pulvermüller, 2005). The present results suggest that this link from word to body part may be pervasive and systematic for the common verbs that children learn early. Further, they suggest that links to the body may be important both for verbs that are unambiguously about actions done by specific body parts (e.g., *kick*) as well for verbs that at first seem to be about relations not so tightly tied to a specific bodily action (e.g., *give*).

Although the present results tell us that speakers of English have considerable shared knowledge about verbs and body parts, they do not tell us how, or if, that knowledge is used in the comprehension of verbs. Traditional research on verb meaning and early verb learning has concentrated on the abstract and relational structure of verbs and their role in sentential syntax (e.g., Fisher, 1994; Gleitman, 1990; Naigles, 1990). Body-part knowledge could be independent of and complementary to these relational aspects of verb meaning. Alternatively, there may be deep relations waiting to be discovered between the kinds of actions that can be performed by different body parts and more relational aspects of verb meanings (see Kemmerer, 2006). Moreover, whatever role body parts play in adults' processing of verbs, it seems likely that they play an even greater role in the moment-to-moment dynamics of acquisition. Children learn verbs in the contexts of their own actions and, consequently, the body part—and the constraints it imposes on action and relational structure—may play a prominent role in the learning and at least initial understanding of verbs.

The overall acquisition pattern—from relatively many mouth verbs, to more hand verbs, to less bodily defined verbs—was unexpected and tantalizing in its similarity to traditional Piagetian (Piaget, 1953) descriptions of the developmental course of sensory-motor development as infants first explore relations in their world. The source of this surprising instance of decalage may ultimately lead to new insights about how verbs are learned, about how they are represented, and about the role of sensory-motor processes in all this. The body is the conduit of experience into the mind and the final pathway through which ideas have their effect on the world. Thus, the study of the body's morphology with respect to action would seem a good starting point for an embodied theory of verb learning.

Acknowledgments

Yo Kimura (daughter of Hanako Yoshida & Gen Kimura) served as the model for the body maps that were prepared by Shravan Rajagopal. This research was supported by National Institutes of Health Grant No. MH60200 awarded to Linda B. Smith.

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Appendix

By alphabetical order, the single-most frequent words associated with each verb and the proportion of participants offering that specific word and the maximum body region (as defined in Table 1), and the proportion of participants whose associated body part fell in that body region.

	Single Body-Part Word	Maximum Body Region
bite	58 MOUTH	98 mouth
blow	54 MOUTH	80 mouth
break	34 HAND	54 hand
bring	76 HAND	98 hand
build	80 HAND	92 hand
bump	36 HEAD	
buy	82 HAND	86 hand
carry	56 HAND	100 hand
catch	90 ARM	98 arm
chase	60 LEG	98 leg
clap	100 HAND	100 hand
clean	82 ARM	88 hand
climb	30 ARM	54 arm
close	56 HAND	70 hand
cook	84 HAND	92 hand
cover	46 HAND	54 hand
cry	98 EYE	98 eye
cut	46 HAND	86 hand
dance	58 FEET	92 leg
draw	82 HAND	98 hand
drink	70 MOUTH	82 mouth
drive	58 HAND	66 hand
drop	80 HAND	88 hand
dry	60 HAND	66 hand
dump	44 HAND	66 hand
eat	82 MOUTH	92 mouth
fall	34 LEG	50 leg
feed	60 HAND	60 hand
find	88 EYE	88 eye
finish	26 HAND	
fit	26 WHOLE BODY	
fix	84 HAND	88 hand
get	62 HAND	74 hand
give	74 HAND	90 hand
go	54 LEG	94 leg
hate	34 MIND	
have	44 HAND	74 hand
hear	100 EAR	100 ear
help	68 HAND	80 hand
hide	40 EYE	
hit	64 HAND	82 hand
hold	68 ARM	98 hand
hug	94 ARM	96 hand

By alphabetical order, the single-most frequent words associated with each verb and the proportion of participants offering that specific word and the maximum body region (as defined in Table 1), and the proportion of participants whose associated body part fell in that body region. *(Continued)*

	Single Body-Part Word	Maximum Body Region
hurry	64 LEG	96 leg
jump	66 LEG	100 leg
kick	70 FEET	96 leg
kiss	62 LIP	98 mouth
knock	50 HAND	78 hand
lick	90 TONGUE	96 mouth
like	26 HEART	
listen	98 EAR	98 ear
look	98 EYE	98 eye
love	54 HEART	
make	90 HAND	94 hand
open	64 HAND	84 hand
paint	74 HAND	92 hand
pick	40 HAND	74 hand
play	34 HAND	
pour	84 HAND	94 hand
pretend	48 MIND	
pull	54 ARM	90 hand
push	50 HAND	88 hand
put	88 HAND	92 hand
read	96 EYE	96 eye
ride	38 LEG	
rip	66 HAND	86 hand
run	60 LEG	94 leg
say	92 MOUTH	96 mouth
see	100 EYE	100 eye
shake	58 HAND	68 hand
share	64 HAND	80 hand
show	50 HAND	56 hand
sing	86 MOUTH	86 mouth
sit	64 BUTTOCK	
skate	72 LEG	96 leg
sleep	48 EYE	
smile	82 MOUTH	94 mouth
spill	80 HAND	88 hand
splash	60 HAND	80 hand
stand	62 LEG	100 leg
stop	48 FEET	66 leg
sweep	70 ARM	86 hand
swim	76 ARM	76 hand
swing	44 LEG	
take	88 HAND	98 hand
talk	94 MOUTH	96 mouth
taste	64 TONGUE	100 mouth
think	40 MIND	

By alphabetical order, the single-most frequent words associated with each verb and the proportion of participants offering that specific word and the maximum body region (as defined in Table 1), and the proportion of participants whose associated body part fell in that body region. *(Continued)*

	Single Body-Part Word	Maximum Body Region
throw	56 ARM	96 hand
tickle	60 FINGER	82 hand
touch	52 FINGER	96 hand
wait	28 LEG	50 leg
wake	60 EYE	60 eye
walk	56 LEG	98 leg
wash	84 HAND	88 hand
watch	90 EYE	90 eye
wipe	66 HAND	66 hand
wish	42 MIND	
work	54 HAND	66 hand
write	84 HAND	94 hand