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An Embodied Account of Argument Structure Development

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Introduction

Theorists of verb learning concentrate on the abstract structure of the knowledge to be acquired and the contexts that support learning. This emphasis on the abstract has led to insights about universal principles (e.g., Lidz, Gleitman, & Gleitman, 2003), the role of parental input (e.g., Tomasello, 2003), shared knowledge and other factors of discourse-pragmatics (Clancy, 2004; DuBois, 1987), gaze and joint attention (Allen, 2007; Skarabela & Allen, 2002; Skarabela, 2007), and information from language itself in verb learning and syntactic development (e.g., Naigles, Gleitman, & Gleitman, 1993; Goldberg, Casenhiser, & Sethuraman, 2004). Researchers have rarely considered the physical properties of the bodies of the learners.

However, all information enters the cognitive system through the body. Thus, it is possible that the body—and its morphology—may also play a role in structuring knowledge and acquisition. This idea is particularly cogent in the case of verbs, since early learned verbs are about bodily actions and since recent advances in cognitive neuroscience (Pulvermueller, 2005; James and Maouene, 2009) indicate that the neural processing of common verbs activates the brain regions responsible for the specific body parts that perform those actions. Here we provide initial evidence these body-part verb relations may also be related to the argument structures associated with specific verbs. We will conclude that in the same way that verb meaning and argument structure develop out of correlations in *linguistic experiences,* they may also develop out of correlations in *body experiences*.

1 Rationale

Study 1 examines the body parts most commonly associated with early-learned verbs by adults and children (36-60 months). This study shows consistent and coherent structure in the association of body-parts and common verbs.

Study 2 examines associations of objects with these verbs. Adults were asked to associate the 101 verbs from the MCDI with one specific object. These analyses provide the basis for a subject (rather than linguist)-based categorization of the verbs as (primarily) Transitive, Instrumental, Subject, Locative, or Other. Using the evidence from Study 1, we then show that these classifications are tightly tied to the body part that performs the action labeled by the verb.

Study 3 examines children's speech (CHILDES) to determine whether these verb-object correlations exist in their speech using the same categorization scheme as in Study 2. Again, there is a strong correlation between body part and syntactic frames.

Study 4 provides a direct test by presenting adults and children with novel verbs in different frames and examining the body parts used to act out the verb.

2 Connecting verbs to body parts

It seems obvious that at least some concrete verbs are about actions done by specific body parts: we *kiss* with our *lips*, we *run* with our *legs*, we *give* and *get* with our *hands*. To examine systematic correlations between body parts and early-learned verbs, Maouene, Hidaka & Smith (2008) asked 50 adults to name the main body part suggested by each of 101 early-learned verbs from the MacArthur Communicative Development Inventory (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 on the MCDI, *stay* and *tear* were omitted by experimental error).

Results: Sixty-one uniquely different body-part words were offered by the participants. However, just 15 unique body-part terms accounted for over 84% of the associations. A correspondence analysis (dimension reduction technique) of the 61 body parts by 101 verbs matrix indicated that the 4 first dimensions accounted for 34.7% of the variance among the judgments and revealed 5 main body part regions: EYE, MOUTH, LEG, HAND, EAR as shown in Figure 1. For the purpose of the present article we collapse EYE, MOUTH, EAR verbs into HEAD related verbs. Of the 101 examined verbs, by this measure, 54 were hand verbs, 13 were leg verbs, and 19 were head verbs. 15 other verbs were related to multiple body regions.

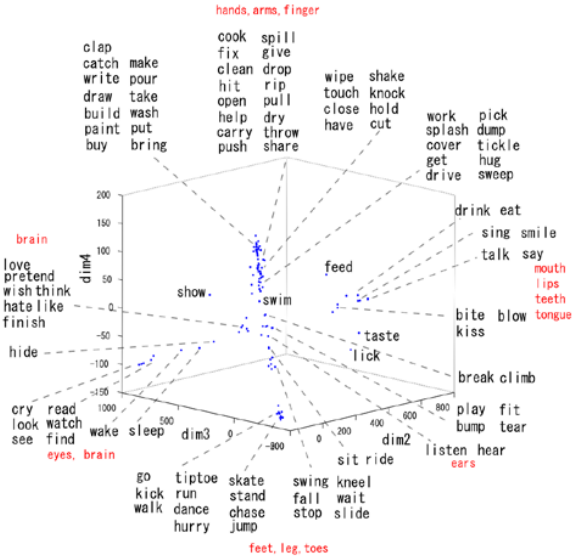

Figure 1. Similarity structure of body part associations in adult judgments. Each verb is a dot. Close verbs have similar body part associations (from Maouene, Hidaka & Smith, 2008).

2.1 Children's Associations of Verbs and Body Parts

Next, we asked 60 children, ranging from 36-60 months of age, to make a comparable judgment on the same 101 verbs by answering the question *What part of your body do you use to* _____*?* Each child saw a subset of 20 verbs, so 10 children total saw the same 20 verbs (some verbs appeared twice for consistency control).

Results: 48 unique body parts were offered by the children. Applying the same dimension reduction technique to the 48 by 101 matrix, we found as seen in Fig. 3, that children form patterns of associations similar to those formed by adults, in that five major regions of the body organize verbs: EYES, EAR, MOUTH, HANDS, LEGS. The correlation between children and adult judgments is strong, $r=0.85$, $p<.001$. Children and adults have the same ideas about how common verbs connect to body parts.

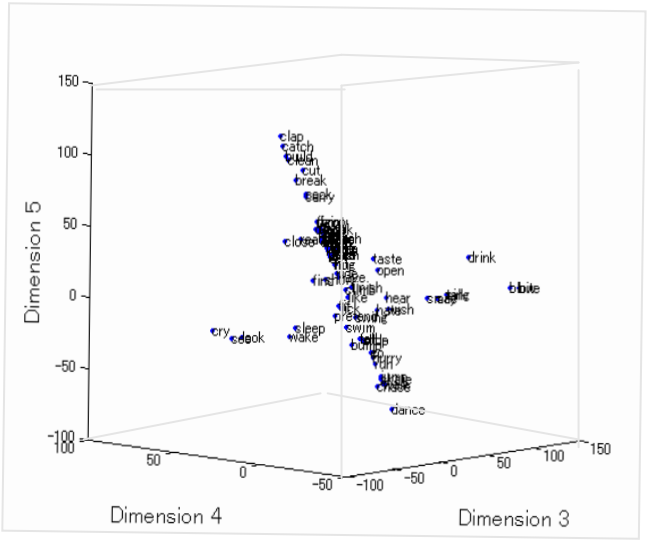

Figure 3. Similarity structure of body part associations in child judgments. Each verb is a dot. Close verbs have similar body part associations.

3 Connecting Verbs, Objects, Transitivity and Intransitivity and Body Parts

As a first step, we examined the *first* dictionary entry of the 101 MCDI verbs as indicating whether that verb was transitive or intransitive. For 74% of the HAND verbs, the verb was transitive by this criterion; 88% of the first dictionary entries for HEAD verbs were transitive; but 88% of the first dictionary entries for LEG verbs were intransitive. This is a first indication of a link between the relational meaning of a verb and the body part that performs the action.

3.1 Adult's Object Associations

A perhaps more direct way to look at transitivity is to ask speakers of the language what kinds of objects "go with" these verbs.

Participants: The participants were 286 college undergraduates, whose native language is American English.

Stimuli: The verbs were 101 transitive verbs from the Bates-MacArthur Communicative Developmental Inventory for American English (MCDI, Fenson, Dale, Reznick & Bates, 1993).

Procedure: Participants were tested individually. Each was given a randomly ordered list of verbs on a computer screen, one verb at a time, and asked to supply (by typing the word on the keyboard) the *one object* that first came to mind given the verb. There were no constraints and no definition of what was meant by "object;" in this way, these are free associations and measure the strength of the connection in semantic memory between the verbs and the produced associate. We chose this metric based on past evidence that adult word associations directly reflect the contiguity, semantic, and frequency properties of words in the language (Deese, 1965). Co-occurrence in particular seems to be a primary factor (Lund,

Burgess, & Audet, 1996; Spence & Owens, 1990), with words that appear together in language more frequently also having a higher likelihood of appearing in associative pairs.

Analyses: For the following analyses we only considered the most frequently named noun for each verb. Then three independent coders sorted the relationship between each verb and its most frequently named object into one of five basic relations: Transitive – Subject – Instrumental – Locative – Other. Finally we considered the preferred body part associations of each of those 101 verbs (from study 1) and the mean percentage of each body region for each relation was computed.

Results: 80 verbs out of 101 were attributed to one of the five categories of interest (Transitive, Instrumental, Locative, Subject, Other) with 100% agreement among the coders after error corrections. The following results consider these 80 verbs. The objects that were coded as standing in a transitive relation with the verbs are Hand verbs (76%). The objects that were coded as standing in an instrumental and transitive relation are Head verbs (respectively 33% and 43% of the sample). The objects that were coded as standing in a locative relation with verbs are mostly Leg verbs (46% of the sample).

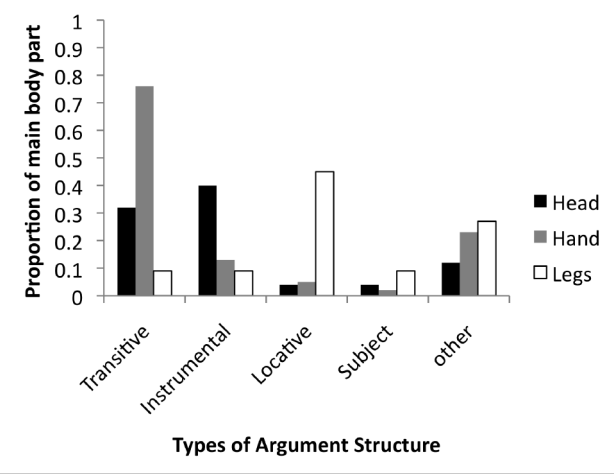

Figure 4: Proportion of main body part associate (from Maouene et al., 2008) per each type of relational structure.

These results, along with the dictionary definitions again suggest a relation between the relational meanings of verbs and the body parts that do the action.

3.2 Co-occurrences Verbs-1st Nouns in CHILDES

Here we seek converging evidence for a relation between the relational meaning of verbs and body parts by examining co-occurrences of verbs and objects in the

CHILDES database (McWhinney, 2000). We chose to examine co-occurrence on three grounds. First, comparisons of adult judgments and co-occurrence patterns in child corpus analyses yield correlated patterns (Kidd & Bavin, 2007). Second, co-occurrence patterns have been shown to be highly reliable indicators of syntactic categories but are, in and of themselves, objective and not dependent on a priori commitments about the properties of the words (Lund & Burgess, 1996). Third, the co-occurrence patterns in the input themselves are part of the data from which children learn verbs and syntactic relations.

All of the corpora, a total of 36, in the American English portion of the database were used. In all, there were 2,163 transcripts comprising 1,481,858 transcribed utterances. Speech by 899 children were analyzed; the children in these conversations ranged in age from 6 months through 10 years, although the majority of children were between 1 to 5 years. The co-occurrence counting procedures used a computer program written in Python using the SciPy libraries (Jones, Oliphant, & Peterson, 2001). The program examined the morphosyntactic coding to identify nouns (pronouns were excluded) and the 101 verbs from Study 1. All forms of a verb (*splash, splashed, splashing*) were considered to be the same verb. For each verb, the program extracted the first noun after the verb. Then three independent coders sorted the relationship between each verb and its most frequently named object into one of five basic relations from the adult associations study: Transitive — Instrumental – Locative – Subject – Other. Finally we considered the preferred body part associations of each of those 101 verbs (from study 1) and the mean percentage of each body region for each relation was computed.

Results: 64 verbs out of 101 were attributed to one of the five categories of interest (Transitive, Instrumental, Locative, Subject, Other) with 100% of agreement among the coders after grammatical error corrections. The following results consider these 64 verbs. The objects that were coded as standing in a transitive relation with the verbs were Hand verbs in 64% of the sample of hand verbs. The objects that were coded as standing in transitive relation were Head verbs in respectively 64% of the sample of head verbs. The objects that were coded as standing in a locative relation with verbs were again mostly Leg verbs in 48% of the sample of leg verbs.

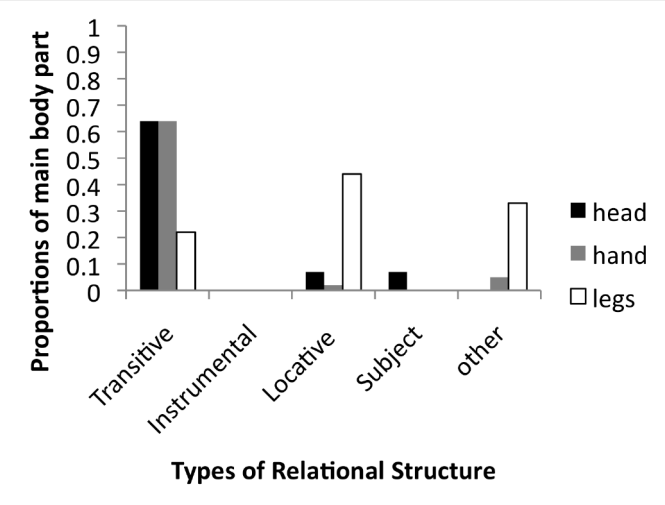

Figure 5: Proportion of the main body part associate (from Maouene et al., 2008) per each relational structure type.

This corpus analysis in conjunction with the adult object associations and the dictionary definitions support the idea that there are systematic associations between the relational meanings of verbs and the body-parts that do the actions. None of the three analyses –dictionary definition, adult associations, CHILDES analysis –are perfect. Yet they all agree. There is structure in the language with respect to a verb's relational meaning and body parts.

4 Connecting body parts to made-up sentences: Body parts to syntactic frames experiment

Do children and adults know and use this structure? To address this question, we gave participants sentences with structured frames and novel verbs and asked them to guess whether the action was performed by hand, head or leg.

The participants were 12 adults, 12 four- to five-year-olds, and 12 five-to six-year-olds, mean age of respectively 57 months and 76 months, who heard eight made-up sentences with different sentential structures, corresponding to [NP V], [NP V NP], [NP V with NP], [NP V to NP], [NP V on NP], [NP V at NP], [NP V NP to NP], and [NP V-S], for a complete list, see Appendix III. We grouped [NP V to NP], [NP V on NP], [NP V at NP] under [NP V loc].

We used pseudo words, each appeared in as a noun or a verb in the experiment. The carrier sentences maintained English determiner and prepositional structures. Participants were given the following instructions: *Let's play a guessing game. You are in a pretend world where people speak a language that is half English and half something else. Let's imagine I can speak this language and I am telling you what you are going to do next. Can you guess if the action will be*

done by the head, the hands or the feet?" To help you out, first I will give you two sentences that in English, all right? Let's start this game!

You will now eat in the kitchen! Head Hand or leg?

You will know get off the bus! Head Hand or leg?

The results are shown in Figures 6-11. They suggest that adults associate frames with body parts and this is so for 4 out of 6 common syntactic frames studied. Overall, the patterns observed in Study 2 are supported in the adult results for [NP V]—HEAD, [NP V loc]—LEG, and [NP V-S]—HEAD AND [NP V INST] HEAD.

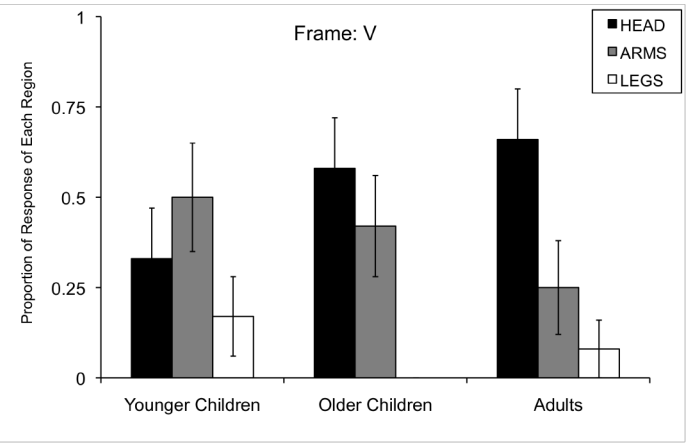

Figure 6. Proportion of choices of head, hand, and leg as associated by 4-year-olds, 5-year-olds, and adults with the frame [NP V]. Example use of frame: *"You will now gorp."*

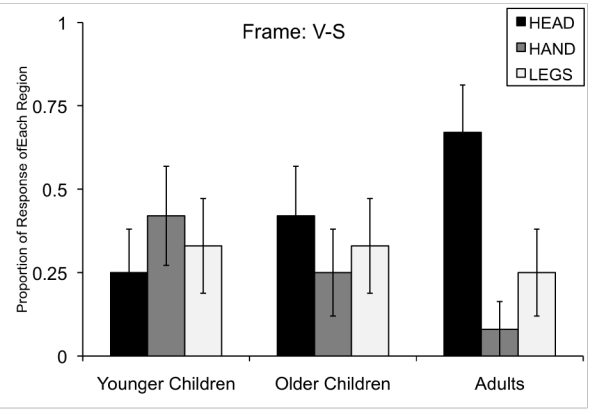

Fig. 7. Proportion of choices of HAND, HEAD, and LEG as associated by 4-year-olds, 5-year-olds, and adults with the frame [NP V-S]. Example use of frame: *"You will now gorp that the dax is bivish."*

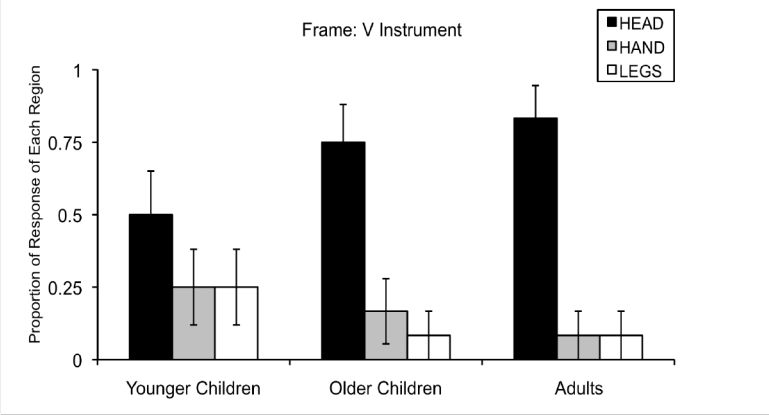

Figure 8. Proportion of choices of HEAD, HAND and LEG as associated by 4-year-olds, 5-year-olds, and adults with the frame [NP V-S]. Example use of frame: *"You will now gorp with the modi"*.

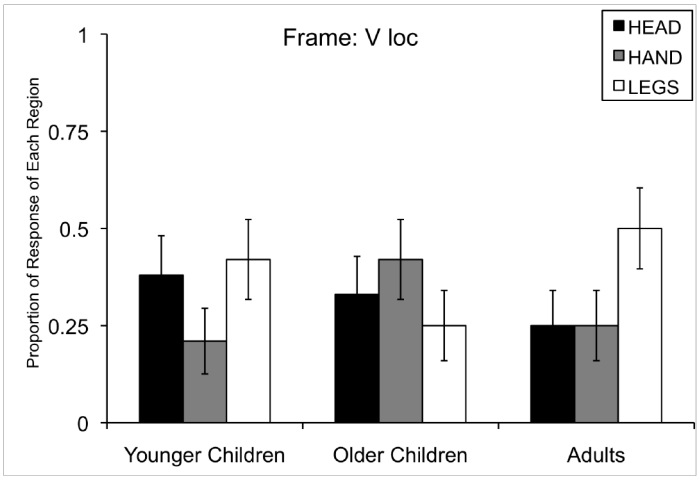

Figure 9. Proportion of choices of, HEAD, HAND and LEG as associated by 4-year-olds, 5-year-olds, and adults with the frame [NP V loc]. Example use of frame: *"You will now gorp on the modi, You will now gorp to the modi."*

The correlative patterns in Study 2 are not supported in the adult results for V NPloc and V NP, see below.

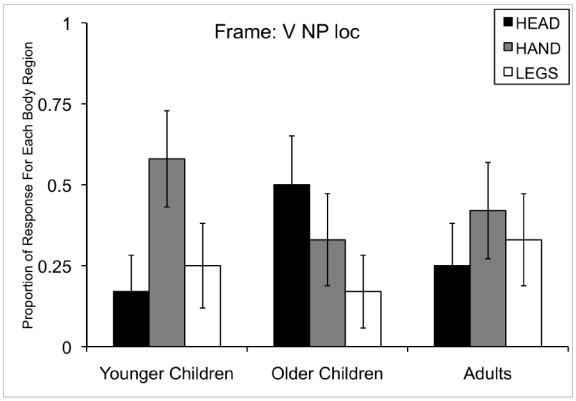

Figure 10. Proportion of choices of HEAD, HAND, and LEGS as associated by 4-year-olds, 5-year-olds, and adults with the frame [NP V NPloc]. Example use of frame: *"You will now gorp the modi to the dax."*

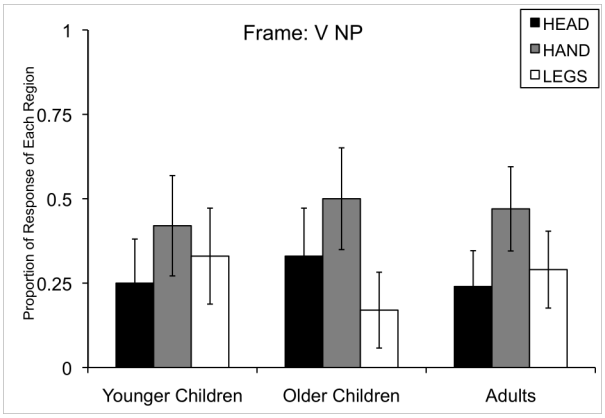

Figure 11. Proportion of choices of HEAD, HAND, and LEGS as associated by 4-year-olds, 5-year-olds, and adults with the frame [NP V NP]. Example use of frame: *"You will now gorp the modi".*

In fact, the V loc is highly ambiguous in terms of body parts, it could be either transitive (hand) or intransitive (leg) if the participants only considered the "locative" part of the frame. Similarly, the V NP could be either transitive (head and hand) or locative (leg).

Older children and younger make a significant association with the most common body part that does the action for 2 out of 6 common syntactic frames. But they differ on which associations they make. Older children were able to infer HEAD for the frame [NP V] and [NP V inst]. There is some suggestion that this is knowledge that develops with age in that younger children show no clear linkage of HEAD with the frame [NP V]. Younger children did show an association of HAND with the frame [NP V NP loc] and [NP V inst]. As shown in Study 1,

HAND verbs are predominant among the early-learned verbs in children, and it may be that younger children rely upon HAND more than other body parts because it is probabilistically more frequent. However, this is an issue that requires further study.

In this study, syntactic frames containing nonce verbs were presented, and the children had difficulty associating particular body parts with particular frames. Adults were able to do the task for four out of six frames. These results suggest that if the verb meaning is absent, children cannot disambiguate between sentential structure well and need additional context, particularly the verb. We infer this from the fact that in the two warming up sentences, all children (younger and older) were at ceiling. Data from studies in different cognitive domains suggest that young children need more information than adults in solving the same problem (Gibson, Michelle Leichtmana, Kunga and Simpson, 2007).

5 Conclusion

Traditional views of cognition, and a fortiori language, separate cognition from emotion, perception and action. However, a number of lines of research—in cognitive neuroscience (Dourish, 2001), in behavioral studies of adult cognition (Barsalou, 2003; Wilson, 2002), in philosophy and linguistics (Lakoff & Johnson, 1999), and in robotics (Anderson, 2003)—suggest that language and cognition are embedded in and not entirely distinct from the processes of feeling, perceiving and acting. This hypothesis, generally referred to as Embodied Cognition, is the idea that cognition is embodied, meaning that cognition, including language, derives from the experiences in the real world that come from the body's interaction with the environment through the perceptual and motor modalities

There are many different positions on what embodiment is, with respect to meaning and representation (Anderson, 2003; Wilson, 2002; Ziemke, 2001)—including the view that even abstract concepts are influenced by perception-action in a dynamic world (e.g., Landy & Goldstone, 2007), perhaps via metaphors related to more concrete meanings (e.g., Matlock, 2004). Indeed, body parts have been found to often be used for this type of "grounding", that is, as a metaphor framing many abstract semantic domains, such as number, space, and emotion, in terms of body parts and physical world experience (de Leon, 1994; Saxe, 1981; Yu, 2004). There are some suggestive ideas that have been put forth that body parts may also play such a metaphoric role in our understanding of verb meaning (e.g., see hints in Richardson, Spivey, Barsalou, & MacRae, 2003), which we would not be surprised if explored and supported by future work.

There may be deep relations waiting to be discovered between the possible actions-perceptions experienced by different body parts and more abstract, relational aspects of verb meanings (see Kemmerer, 2006), as suggested by the results presented here. The present results suggest that links 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., get, go, put). The present results also tell us that mature speakers of English have considerable shared knowledge about verbs and body parts and that this knowledge is used in the comprehension of verbs and syntactic frames; the results further suggest that this knowledge is developing in 4- to 6-year-olds. Granted, we present here a correlational study and further work need to address these ideas further, but many results from different researchers using different methods, both in adults and in children, suggest that the idea of an embodied path to early language learning should be examined thoroughly.

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