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To cite this article: Penny M. Pexman (2017): The role of embodiment in conceptual development, Language, Cognition and Neuroscience, DOI: 10.1080/23273798.2017.1303522

To link to this article: http://dx.doi.org/10.1080/23273798.2017.1303522

Published online: 20 Mar 2017.
The role of embodiment in conceptual development

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ABSTRACT
It is well established that sensory experience is influential in children’s early concepts. Opinions diverge, however, on the role of sensorimotor experience in conceptual development beyond infancy. In this paper I review theories of embodied conceptual development, which hold that sensorimotor experience continues to be important to children’s concepts beyond the first two years. In evaluating those theories, I describe studies that have examined embodied effects in children’s conceptual and language processing, and suggest that many unanswered questions remain. One of the biggest challenges for embodied accounts of conceptual development is to explain how abstract concepts are learned and represented. I review the proposals that have been offered to explain development of abstract concepts, and argue that by tackling this challenge we will gain insight about the viability of models of embodied and grounded cognition more broadly.

Theories of embodied cognition
There are now a number of different proposals for embodied cognition. As outlined by Meteyard, Rodriguez Quadrado, Bahrami, and Vigliocco (2012), these can be characterised on a continuum from unembodied to strongly embodied. Traditional cognitive theories that emphasised amodal symbol manipulation and cast sensorimotor systems primarily as input/output devices (e.g. Fodor, 1983; Newell & Simon, 1976; Pylyshyn, 1985) could be placed at the unembodied end of the continuum. In contrast, theories at the strongly embodied end of the continuum propose that sensorimotor systems are essential to cognitive processing and that cognition cannot be separated from perception, action, and emotion systems (for reviews see, e.g. Gallese & Lakoff, 2005; Glenberg, 2015). Most theories fall between these poles, including proposals that while sensorimotor and cognitive systems interact, most cognition occurs independent from perception and action (for reviews see Mahon, 2015; Mahon & Caramazza, 2008). The consensus view, one I share, also falls between the poles of the embodiment spectrum. I propose that conceptual representations are multimodal, involving perceptual, motor, sensory, emotion, and language systems (Hargreaves & Pexman, 2014; Yap, Pexman, Wellsby, Hargreaves, & Huff, 2012). With representation distributed across systems, processing is assumed to be dynamic, varying with stimulus (Sidhu, Kwan, Pexman,
Embodied conceptual development

The view of a dynamic, multimodal conceptual system has emerged primarily from work on adult concepts and language processing. There is still much to learn, however, about how this system develops. As others have noted, there has been little crosstalk between the adult and child embodied cognition literatures (for reviews see Antonucci & Alt, 2011; Marshall, 2016; Pexman, 2012). It has long been assumed that children’s first concepts emerge out of their sensorimotor interactions with the world (Piaget, 1952). Further, there is evidence that changes in children’s motor behaviours, such as development of sitting and standing, have consequences for their concepts. For instance, Soska, Adolph, and Johnson (2010) examined the influence of self-sitting skills on 4.5–7.5 month-old infants’ ability to perceive objects as complete 3D forms (to infer the unseen backs of objects), a perceptual achievement which typically emerges around the middle of the first year. Soska et al. found that self-sitting ability, not age, was the best predictor of 3D object completion. They argued that this was because independent sitting affords infants opportunities to manipulate objects, and these new visual and tactile experiences provide information about object form. This shift in experience as a function of motor development is consistent with recent research from naturalistic recordings showing that over the first two years of life infants’ visual experience transitions from a preponderance of faces to a preponderance of their own and others’ hands (Fausey, Jayaraman, & Smith, 2016).

Similarly, in a longitudinal study, Karasik, Tamis-LeMonda, and Adolph (2011) showed that the changes that occur in infants’ interactions with objects at around 1 year (including more intentional and instrumental interactions with objects) are linked to the infants’ physical transition from crawling to walking. That is, walking changed infants’ access to and engagement with objects, affording access to more distant objects, the ability to carry objects, and new ways to share objects with others. Further, research has shown the importance of sensory input to concept and word learning; for instance, Pereira, Smith, and Yu (2014) demonstrated that 20-month-old infants learned object names best when a labelled object was clear and central in the child’s field of view, often because the child was holding the object. As such, changes in children’s physical development are linked to changes in their interactions with objects, which likely influence their conceptual development.

In sum, research with very young children (under 2 years of age) suggests that their concepts are shaped by their physical experiences, including action, spatial location, and proprioceptive states (for comprehensive reviews see Smith, 2005, 2013; Smith, Maouene, & Hidaka, 2007). During the same period, children begin to label these categories (Howell et al., 2005) and label learning is influenced by sensory experience (Pereira et al., 2014). Thus, infant concepts emerge from sensorimotor experience. As such, the results are consistent with Piaget’s assumption that sensorimotor experience is relevant to learning in infancy. Opinions diverge on the issue of what happens next. Whereas Piaget suggested that older children developed stable concepts that increasingly involved symbolic representation, separate from sensorimotor experience, others have argued that action and perception continue to influence knowledge throughout the lifespan (for a review see Kontra, Goldin-Meadow, & Beilock, 2012).

A handful of embodied theories offer specific proposals about how children’s concepts might develop; I describe three theories here. First, Howell, Jankowicz, and Becker (2005) proposed a computational model of grounded language acquisition. Howell et al. assumed that children’s early sensorimotor-based concepts ground subsequent word learning: “early concepts provide scaffolding by which later word learning, and even grammar learning, is enabled and facilitated” (p. 258). Later words may not refer to concepts that are as physically or perceptually salient as early words; Howell et al. argued that later words can be acquired by their associations to already known words. These associations are often inferred from the linguistic contexts in which words are used, as instantiated in lexical co-occurrence models (e.g. the Latent Semantic Analysis (LSA) theory of acquisition, Landauer & Dumais, 1997). Thus, in the Howell et al. model, words have two sources of meaning: (1) direct experience, and (2) indirect relations to other words. To incorporate these assumptions, Howell et al.’s model included sensorimotor features to capture knowledge acquired from direct experience. Simulations showed that the inclusion of sensorimotor features improved the model’s accuracy in word prediction, consistent with the claim that sensorimotor knowledge is advantageous to early language learning (see also Andrews, Vigliocco, & Vinson, 2009).
Second, Dove (2011) proposed that concepts are represented in two interacting sensorimotor systems: (1) a multimodal embodied representation system that captures our sensorimotor experiences with objects and entities in the world, and (2) a language system, which represents our linguistic experiences. The second system is built on the first, and in this way it is similar to the Howell et al. proposal; as language is acquired, it extends the multimodal embodied system and makes it possible to generalise across situations and experiences. As such, language acquisition modifies the conceptual system. Similarly, Clark (2008; see also Vygotsky, 1986) described language as cognitive scaffolding, extending the embodied mind: “the act of labeling creates a new realm of perceptible objects upon which to target basic capacities of statistical and associative learning” (p. 45). The label can be a tool for grouping, directing attention to all objects in a particular category (Waxman & Markow, 1995). When the same label is applied to a variety of perceptual objects, the label invites the learner to seek out the “perceptual commonality” of those objects (Clark, 1998, p. 168). Indeed, Lupyan, Rakison, and McClelland (2007) found that providing nonsense category labels helped adults learn to categorise novel objects, and suggested that language does more than direct attention. Labels help learners represent category distinctions. Thus, by this view, language acquisition builds upon and complements the conceptual system.

Third, Glenberg and Gallese (2012) took a different approach to language acquisition in their Action-Based Language theory. Glenberg and Gallese argued that the human brain allows a tight coupling of action control and language. That is, speech and action are processed and controlled in similar brain regions, in particular, via overlapping regions of Broca’s area. Children map labels to concepts via a Hebbian learning mechanism, wherein heard object names are bound to the actions associated with an object. Once learned, children can hear (or read) a label and access an image of the labelled object, as well as actions associated with the object. These learning and retrieval processes are proposed to be similar for object labels (nouns) and action labels (verbs). Action experience is assumed to be an important aspect of conceptual representation, so the theory predicts that children will more readily learn labels for concepts with which they have action experience. In fact, Glenberg and Gallese go so far as to predict that for nouns and verbs “learning will occur only after the child has learned appropriate actions, either interactions with objects or goal-directed actions such as giving” (p. 913). Thus, action experience is assumed to be a necessary condition for word learning, and to play a critical role in conceptual processing even in adulthood. While the Howell et al. and Dove theories are examples of weak embodiment theories on the Meteyard et al. (2012) continuum, the Glenberg and Gallese account is an example of a strong embodiment account. The former theories assume that concepts are partly dependent on sensorimotor systems, while the latter assumes complete dependence.

Despite their differences, each of these theories predicts that early concepts emerge from sensorimotor experience. As such, they are each supported by the evidence that sensorimotor information is important to the development of concepts in infancy (e.g. Smith, 2005). Less research attention has been given to the role of sensorimotor information in conceptual knowledge beyond the first two years, and it is here that the theories would make different predictions. Thus, many of the predictions that could be derived from these theories have yet to be tested. I next review some of the studies that have addressed the role of embodied experience in children’s concepts beyond infancy, and then return to a discussion of unanswered questions.

**Embodied effects in children’s concepts**

One of the predictions derived from embodied accounts of conceptual and language development is that acting should be a more effective learning strategy than observing. This is because acting involves more sensorimotor experience than does observing. Indeed, Huttenlocher, Smiley, and Charney (1983) found that at about 2 years of age, children had better comprehension of verbs they enacted than of verbs they observed. In contrast, Schwarz, Van Kleeck, Maguire, and Abdi (2016) tested slightly older children (aged 2;6) and found that children’s verb comprehension was not improved when they acted out verb meanings with dolls. Instead, children’s verb learning was enhanced by the analogical reasoning process of comparison, with better comprehension from similar vs. dissimilar visual scenes. These results suggest that while young children benefit from sensorimotor recruitment, older children may benefit from other learning strategies. It is notable, however, that children in the Schwarz et al. study used dolls for action, whereas children in the Huttenlocher et al. study acted with their own bodies. This difference in procedure may have influenced the results, potentially attenuating effects of action in the Schwarz et al. study.

In an fMRI study, James and Swain (2011) explored differences in the neural correlates of verbs learned through self-generated actions vs. observed actions. Children aged 5–6 years were taught novel verb labels while performing an action on an object or watching
an experimenter perform an action on an object. Later, during an fMRI session, children heard the verbs and saw photographs of the objects. Results showed activity in the motor cortex during passive listening to verbs learned through self-generated actions but not for verbs learned through observed actions. Similarly, motor system activation was greater when children viewed objects experienced through active interaction than when children viewed objects experienced through observed interactions. These findings support the assertion that learning through action involves more recruitment of sensorimotor brain regions than learning through observation, and the claim that children’s word meanings can be grounded in action (see also James & Maouene, 2009).

In related work, Hald, van den Hurk, and Bekkering (2015) tested a prediction derived from Glenberg and Gallese’s (2012) Action-Based theory of language acquisition; that is, congruent motor actions should facilitate word learning. In this case, meaning-congruent actions were conveyed via animation and also via pictures, and the hypothesis derived from the Action-Based theory was that animations should be a more effective means than pictures to facilitate verb learning. Participants were 7- and 8-year-old children, and the paradigm involved presentation of novel verbs in sentence contexts, along with meaning-congruent (correct action depicted) or meaning-incongruent (incorrect action depicted) animations or pictures. As expected, learning was most successful in meaning-congruent conditions, and with animations rather than pictures. Hald et al. inferred that the enhanced learning they observed was due to children simulating the action depicted in the animation, leading to more accurate representations of verb meaning.

Similarly, Mounoud, Duscherer, Moy, and Perraudin (2007) investigated whether watching a pantomimed action on video facilitated children’s naming (Experiment 1) and categorisation (Experiment 2) of a tool associated with that action. Priming effects were observed, especially among the younger children tested (5- to 9-year-olds), and diminished around 11 years of age. Mounoud et al. inferred that the meanings of object concepts are grounded in action, consistent with Glenberg and Gallese’s (2012) Action-Based account. Mounoud et al. proposed that younger children showed larger priming effects because they were likely experiencing more conceptual change. It is also the case, however, that the younger children were slowest to respond. As a result, their responses may have been more sensitive to priming, not because of conceptual change but rather because slower responses present more opportunity for facilitation.

The prediction that action experience may play a role in development of object concepts was also tested by Kalénine and Bonthoux (2008). In particular, they examined whether children’s conceptual processing involves reactivation of sensorimotor experience with objects. Children were presented with picture triads, and for each triad were asked to judge which two pictures went best together. Results showed that 5-year-old and 7-year-old children were faster to detect associative relationships (jacket-hanger; spoon-yogurt) for manipulable objects than for nonmanipulable objects, suggesting that children relied on action schemas developed through interactions with objects to make decisions about manipulable objects. In contrast, children were faster to detect taxonomic relationships (mosquito-fly; jacket-coat) for nonmanipulable objects than for manipulable objects, suggesting that children relied on perceptual similarity to make decisions about nonmanipulable objects. The authors took this as evidence that manipulable and nonmanipulable objects are represented differently, even in children as young as 5 years of age. Manipulable objects are associated by action and use, whereas nonmanipulable objects are associated by visual similarity. The results of this study suggest that different types of sensorimotor experience are important for development of different kinds of concepts.

In a recent study, Inkster, Wellsby, Lloyd, and Pexman (2016; also Wellsby & Pexman, 2014b) also tested the notion that sensorimotor experience might be important to children’s object concepts, even in the early school years. Inkster et al. investigated the effects of words’ rated body–object interaction (BOI; Siakaluk, Pexman, Aguilera, Owen, & Sears, 2008) on children’s word recognition performance. BOI is a variable that has been shown to influence adults’ language processing: lexical and semantic decisions are facilitated for words that refer to objects that are easier for the human body to physically interact with (high BOI, e.g. mask), than to words that refer to objects that are more difficult for the human body to physically interact with (low BOI, e.g. ship; Siakaluk, Pexman, Sears, et al., 2008). To be clear, these words all refer to concrete and highly imageable concepts, but the concepts differ in the extent to which they afford easy physical interaction. BOI effects have been found in a number of studies with adult participants (Phillips, Sears, & Pexman, 2012; Tousignant & Pexman, 2012; Wellsby, Siakaluk, Owen, & Pexman, 2011) and such effects suggest that adults access information about their sensorimotor experience with words’ referents in lexical and semantic tasks. Indeed, in an fMRI study with adult participants, Hargreaves et al. (2012) found that semantic decisions to high BOI
words (vs low BOI words) were associated with greater
activation in the left inferior parietal lobule (supramargi-
nal gyrus, BA 40), a sensory association area involved in
kinesthetic memory.

In the Inkster et al. (2016) study, BOI effects were
examined using a word recognition task that was well
suited to younger children’s language processing skills.
That is, children were simply asked to repeat aloud the
words they heard spoken through headphones. Using
this auditory word repetition task, Inkster et al. found
that 6- to 7-year-old children showed a BOI effect, with
faster latencies for high BOI words than for low BOI
words. The effect was largest for the older children in
this age range. Inkster et al. also tested for an imageabil-
ity effect, which involves faster latencies for words that
are easily imageable (e.g. truck) than for words that are
not easily imageable (e.g. truth). Results showed a
robust imageability effect across the age range tested.
The results suggest that sensorimotor experience is
important to children’s lexical knowledge, and that
while body-based motor experience (BOI) may be influ-
ential by about 7 years of age, visual perceptual experi-
ence (imageability) may be influential even earlier,
before 6 years of age. This could be because it is possible
to experience almost all concrete objects through visual
observation, but only certain concrete objects can be
experienced through physical manipulation: we regularly
see objects but we only sometimes interact with those
objects. Thus, visual experience may be readily retrieved
from word stimuli, even in younger children, whereas it
take longer to build up representations of body-
based manipulation experience that are retrieved from
word stimuli.

As illustrated in some of the studies reviewed here,
one of the challenges involved in studying embodied
effects in children’s concepts is finding tasks that are
appropriate for assessing children’s conceptual and
language skills across ages. This problem was avoided
in a recent study reported by Thill and Twomey (2016).
Thill and Twomey examined words’ age of acquisition,
using the MacArthur Bates Communicative Development
Inventory norms. Analyses showed that high BOI words
tended to be acquired earlier than low BOI words, even
when factors like word frequency and imageability
were statistically controlled. This result may reflect the
tendency for early concepts to be those that are
grounded in the body. Similarly, Maouene, Hidaka, and
Smith (2008) found that the order of acquisition for
verbs could be predicted, to some degree, by the
relationship of the verb to the child’s developing motor
system. That is, the earliest acquired verbs tended to
be those associated with the mouth, with verbs associ-
ated with hand and arm actions acquired next, and
verbs not associated with any particular body part
acquired later. This suggests, again, that sensorimotor
experience is coupled with language acquisition.

Finally, in research with a more applied focus, Glen-
berg and colleagues investigated whether physical
manipulation experience can enhance children’s
reading comprehension (Glenberg, Goldberg, & Zhu,
2009; Glenberg, Gutierrez, Levin, Japuntich, & Kaschak,
2004) and math problem solving (Glenberg, Willford,
Gibson, Goldberg, & Zhu, 2012). In one study, first and
second grade children read short passages and either
used small toys to enact the events described in the
text or simply read the text without enacting (Glenberg
et al., 2004). Children who enacted the events with toys
had more accurate recall of story ideas than did children
who simply read the text. Glenberg and colleagues took
findings like these as evidence for the Indexical Hypo-
thesis, their embodied account of language comprehen-
sion. This account assumes that meaning is derived
from sentences when words are mapped to experiences
and experiences are integrated into a mental model of
text. Physical manipulation facilitates those mapping
and simulation processes.

Thus, there is evidence that action and sensorimotor experience may continue to be important aspects of con-
cepts and word meanings beyond infancy. As such, the
findings are for the most part consistent with the embo-
died theories of conceptual development reviewed
above (i.e. Dove, 2011; Glenberg & Gallese, 2012;
Howell et al., 2005). Yet some of the studies also
suggest that the story may be more complicated; there
may be contexts (e.g. particular ages or particular tasks)
in which children do not rely on sensorimotor experience
to learn or retrieve concepts (Schwarz et al., 2016;
Wellsby & Pexman, 2014b). The empirical data from
developmental studies are limited, however, and the
studies conducted so far have really only investigated
effects of sensorimotor experience on learning action
verbs and concrete nouns. Arguably, the biggest chal-
lenge to theories of embodied cognition lies in account-
ing for abstract concepts (Barsalou et al., 1993; Mahon &
Caramazza, 2008). That is, while it is clear how embodied
cognition might explain grounding of meanings for con-
cepts that are rich in sensorimotor information, like con-
crete objects and observable actions, it is more
challenging for embodied cognition to explain ground-
ing of meanings for abstract concepts, like truth, since
these cannot be directly experienced through the
senses. This issue has been given considerable attention
in the adult literature in recent years (e.g. Dove, 2016;
Pecher, Boot, & Van Dantzig, 2011; Recchia & Jones,
2012; Zdrazilova & Pexman, 2013). I would argue that
an effective way to gain new insight on this issue, and
to evaluate various accounts that explain grounding of abstract meaning, is to turn attention to the challenge of how abstract concepts are learned.

**Development of abstract concepts**

There are at least three proposals that have been offered to explain how abstract concepts are learned. The first is that the meanings of abstract concepts are grounded through conceptual metaphors (e.g. affections is warmth, Lakoff & Johnson, 1980, for a review see Gibbs, 2006), which map abstract concepts to sensorimotor experience. Lakoff (2012) proposed that as children learn these metaphors, they develop conceptual metaphor circuits and these circuits structure everyday thought. Murphy (1996; also Dove, 2011) noted that a problem with this approach as an explanation for how children learn abstract concepts is that children’s capacity for metaphorical thinking is not fully developed until quite late in middle childhood (e.g. Winner, Rosenstiel, & Gardner, 1976). There are, however, a number of cognitive developments that are considered precursors to metaphorical thinking, and these emerge much earlier (Vosniadou, 1987). For instance, at about 4 years of age children distinguish nonliteral from literal similarity (Vosniadou & Ortony, 1983). It is not clear whether these earlier developments in children’s nonliteral thinking might contribute to conceptual grounding, and so the developmental plausibility of this account is uncertain.

Second, it has been proposed that abstract concepts are learned through language (e.g. Andrews & Vigliocco, 2010; Antonucci & Alt, 2011; Barsalou & Wiemer-Hastings, 2005; Borghi, Flumini, Cimatti, Marocco, & Scrorilli, 2011; Clark, 1998; Crutch & Warrington, 2005; Dove, 2014; Paivio, 1991). In a study with adults, Borghi et al. (2011) tested the idea that language is particularly important to the acquisition of abstract concepts. They reported that learning of novel abstract concepts was facilitated by verbal explanations, but that learning of novel concrete concepts was not. By this view, it is the acquisition of language that makes it possible to learn and represent abstract concepts. The proposal that abstract meaning is grounded through language is difficult to reconcile with a strongly embodied developmental theory like that of Glenberg and Gallesse (2012), but is certainly consistent with weak embodiment or hybrid models like those proposed by Dove (2011) and Howell et al. (2005). Dove proposed that language provides the child with new representational capacities (e.g. linguistic perceptual symbols) that are helpful with all kinds of concepts, and are particularly helpful with representing abstract concepts. Howell et al. suggested that the first words that children learn will likely be concrete words, for which meanings are grounded in direct experience. Later, as abstract words are acquired their meanings are grounded by linguistic experience, and by relationships to earlier-learned words. According to the Howell et al. model, children’s representations of lexical co-occurrence information become increasingly sophisticated, eventually approximating something like the Hyperspace Analogue to Language Model (HAL, Lund & Burgess, 1996) or LSA (Landauer & Dumais, 1997).

Finally, a newer idea is the proposal that abstract meaning is grounded through emotion (Barsalou & Wiemer-Hastings, 2005; Kousta, Vigliocco, Vinson, Andrews, & Del Campo, 2011; Newcombe, Campbell, Siaikaluk, & Pexman, 2012). The argument is that emotional experience should be considered part of the embodied information that plays a role in conceptual processing. While all concepts are represented by a combination of experiential and linguistic information (Andrews et al., 2009; Vigliocco, Meteyard, Andrews, & Kousta, 2009), different aspects of experience are relatively more important for different types of words: sensorimotor experience dominates representations for concrete words, whereas emotional experience dominates representations for abstract words (Kousta et al., 2011; Moffat, Siaikaluk, Sidhu, & Pexman, 2015; Newcombe et al., 2012; Siakaluk, Knol, & Pexman, 2014). Abstract words tend to be more valenced than concrete words (Altarriba, Bauer, & Benvenuto, 1999), making emotion an important strategy for learning and grounding abstract meaning. By this position, abstract meanings could be grounded in embodied experience, via introspective emotion states.

Kousta et al. (2011) proposed that emotion provides a mechanism for children to learn abstract concepts and their labels. An important step in the development of abstract concepts occurs when children learn labels for their emotions, mapping language to their felt experience. By 2 years of age, most children have acquired at least a handful of emotion words (Wellman, Harris, Banejje, & Sinclair, 1995). Kousta et al. argued that in learning labels for internal emotion states children learn that words can refer to entities that do not have an external, perceptual referent. Thus, “emotion may provide a bootstrapping mechanism for the acquisition of abstract words” (p. 26). Kousta et al.’s analysis of age of acquisition ratings for abstract words showed that valenced abstract words were rated as having been acquired earlier than neutral abstract words (e.g. space, fashion). Neutral abstract words are acquired later, perhaps through experiencing their use in the context of other words. Indeed, there is evidence that contextual information is important to adults’ knowledge of abstract words (Barsalou & Wiemer-Hastings, 2005; Crutch & Warrington, 2005).
Since emotional development continues throughout childhood (Stroufe, 1996), it seems likely that early grounding in emotion may be more about valence (good/bad, pleasant/unpleasant) than about more complex emotions, which develop later.

To my knowledge, none of these proposals for grounding abstract meaning have yet been tested in child studies. It will be important to investigate whether children’s early abstract concepts are grounded through metaphor, language co-occurrence, and emotion. Certainly, each of these mechanisms will be developing as the child does, and thus the nature of these mechanisms for grounding likely changes along with the child’s capacity for metaphorical thought, their language skills, and their emotional development. By investigating which strategy or strategies children use at different ages as they learn and retrieve abstract concepts, we will gain insight about which mechanisms need to be built into models of embodied and grounded cognition more broadly. There is evidence that each of these mechanisms may be relevant to adult conceptual processing (for a review, see Dove, 2016), although very few adult studies have examined the simultaneous influences of multiple mechanisms for grounding abstract meaning (cf. Recchia & Jones, 2012; Zdrazilova & Pexman, 2013). My proposal is that all of these mechanisms and more may be relevant to learning and representing the meanings of abstract concepts. Their relevance, however, could shift depending on the child’s cognitive development, the type of abstract concept, and the task conditions. For instance, early abstract concepts might be learned through emotion, and then somewhat later through language and context, and then conceptual metaphor. This sequence seems plausible given what we know about differences in the development of children’s emotion understanding, language skills, and capacities for metaphorical thinking.

Further, there has been a tendency to characterise abstract concepts as a homogeneous category, fuelled by definitions of abstract concepts that have focused on what they are not. We have tended to describe abstract concepts as those that lack perceptual referents, as in “an abstract concept refers to entities that are neither purely physical nor spatially constrained” (Barsalou & Wiemer-Hastings, 2005, p. 129). Such definitions ignore the diversity of abstract concepts, and the features that may characterise the different types. That is, abstract concepts include emotions, mental states, personality traits, scientific terms, relations, events, etc. It seems likely that there are developmental differences in the acquisition of these varied concepts, and that by investigating that possibility we might provide new insight about the how the meanings of each type of abstract concept are grounded.

Thus, embodied accounts of conceptual development face a number of challenges and many unanswered questions. The difficulty of explaining how the diversity of human concepts can emerge across development helps highlight how any theoretical account built on a single dimension of embodiment is unlikely to be successful. I suggest that a multidimensional, hybrid account offers the best path forward. In that way my view is most compatible with the developmental accounts of Howell et al. (2005) or Dove (2011). Such an account will involve a generous interpretation of what “sensorimotor” experience entails, including perceptual, motor, proprioceptive, and introspective states. Further, language experience needs to be incorporated as an important shaper of concepts, one that extends the conceptual system and likely interacts with other mechanisms in complex ways. Linguistic experience is particularly important to the learning and representation of abstract concepts, but is almost certainly not the only dimension of experience that grounds abstract meaning. There is a great deal of work left to do in understanding the relative roles of each of these types of information in conceptual and language processing, from infancy to adulthood. While challenging, this work will be of great importance in order that we fully consider the potential of embodied cognition to help answer the difficult question of how concepts develop.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by a Discovery Grant from the Natural Sciences and Engineering Research Council (NSERC) of Canada [RGPIN/217309-2013].

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