Grounding words and using labels: Linguistic and conceptual knowledge in early cognitive development

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GROUNDING WORDS AND USING LABELS: LINGUISTIC AND CONCEPTUAL KNOWLEDGE IN EARLY COGNITIVE DEVELOPMENT

FUNDAMENTANDO PALAVRAS E USANDO RÓTULOS: CONHECIMENTO LINGUÍSTICO E CONCEITUAL NO DESENVOLVIMENTO COGNITIVO INICIAL

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ABSTRACT: Children typically acquire linguistic and conceptual knowledge simultaneously, allowing reciprocal beneficial effects. However, there is still considerable debate about the nature of both knowledge systems and the extent to which the two knowledge systems interact. A growing body of evidence supports the view that conceptual knowledge and language acquisition and use are grounded in situated action, which has led to the formulation of various theories of embodied cognition and language. Yet there is also considerable evidence that language also exerts important effects on conceptual knowledge. This paper reviews such theories and evidence in relation to research into infants' early conceptual knowledge. Despite the importance of categories and categorical relations for conceptual knowledge, research suggests that early conceptual knowledge may be organized based on situational or thematic relations. Categorical relations may depend on language acquisition because they are abstract relations, and this may be a key aspect in which linguistic knowledge influences conceptual knowledge during development and across the lifespan.

KEYWORDS: Embodied Cognition; Conceptual Development; Categories; Infant Word Learning

RESUMO: As crianças tipicamente adquirem conhecimento linguístico e conceitual simultaneamente, permitindo efeitos benéficos recíprocos. No entanto, ainda há debate considerável sobre a natureza de ambos os sistemas de conhecimento e a extensão na qual os dois sistemas de conhecimento interagem. Um corpo crescente de evidências apoia a visão de que o conhecimento conceitual e a aquisição e uso da linguagem estão fundamentados na ação situada, o que levou à formulação de várias teorias da cognição e linguagem corporificadas.

Contudo, também há evidências consideráveis de que a linguagem exerce efeitos importantes sobre o conhecimento conceitual. Este artigo revisa tais teorias e evidências em relação à pesquisa sobre o conhecimento conceitual inicial de bebês. Apesar da importância das categorias e relações categoriais para o conhecimento conceitual, pesquisas sugerem que o conhecimento conceitual inicial pode ser organizado com base em relações situacionais ou temáticas. As relações categoriais podem depender da aquisição da linguagem porque são relações abstratas, e este pode ser um aspecto-chave no qual o conhecimento linguístico influencia o conhecimento conceitual durante o desenvolvimento e ao longo da vida.

PALAVRAS-CHAVE: Cognição Corporificada; Desenvolvimento Conceitual; Categorias; Aprendizagem de Palavras na Infância.

RESUMO PARA NÃO ESPECIALISTAS: As crianças geralmente aprendem a linguagem e os conceitos ao mesmo tempo, o que significa que palavras e conceitos podem se influenciar mutuamente. No entanto, essa ideia, e a própria natureza da linguagem e dos conceitos, são tópicos debatidos. Aqui, eu reviso evidências de que tanto a linguagem quanto os conceitos são aprendidos através da experiência com o mundo e com outras pessoas, apresentando pesquisas sobre como bebês aprendem sobre objetos e as palavras usadas para nomeá-los. Embora muitas pesquisas tenham estudado como os bebês aprendem a categorizar objetos como certos tipos (por exemplo, animais ou mamíferos), o conhecimento inicial sobre objetos pode estar mais baseado em propriedades físicas e rotinas diárias (por exemplo, aprender sobre animais de estimação e animais de fazenda). São revisadas evidências que sugerem que uma das maneiras pelas quais a linguagem influencia o conhecimento conceitual é ajudando bebês e crianças a aprender sobre relações entre objetos que são usadas para formar categorias.

INTRODUCTION

The ability to form concepts of different kinds of objects, which includes discerning their features or properties and their resemblances to other objects, is fundamental to human cognition (e.g., James, 1890). However, the nature of conceptual knowledge, how adults and children learn new concepts, and the relation between concepts and words, are still debated (e.g., Margolis; Laurence, 2015; Murphy, 2002). This paper offers a narrative review of the literature and aims to provide a (noncomprehensive) synthesis of research on these topics, focusing on infant cognitive development and organized according to two key assumptions. First, forming concepts of entities is an inherently social and experiential process (e.g., Antonucci; Alt, 2011; Kirmayer *et al*., 2020; Piaget, 1953; Tomasello, 2008). Second, all typically developing children also learn at least one language that provides labels for these concepts (e.g., Bloom, 2000; Tomasello, 2003)

and may therefore influence their acquisition (e.g., Connell; Lynott, 2013; Dove *et al*., 2022; Pavlenko, 2014; Whorf, 2011).

One issue in addressing these topics is terminological agreement. The term semantic is used to refer to both concepts and word meanings, yet there is no consensus on what semantic knowledge is or how it is stored and processed (Gainotti, 2017). Conceptual knowledge has typically been investigated in terms of taxonomic categories (i.e., superordinate and coordinate entities; for a review, see Murphy, 2002), which can lead to the conflation of concepts with categories. For example, Antonucci and Alt (2011) distinguished between semantic features as components of concepts and categories as relations between concepts, whereas Murphy (2002) defined concepts as "a nonlinguistic psychological representation of a class of entities" (p. 335). The infant literature has, understandably, focused on concrete concepts of objects.

However, even concrete concepts and categories elude a complete and exclusive definition (Wittgenstein, 1953/2009); concepts are not just fuzzy or ill-defined, but also context dependent (Barsalou, 1983). Likewise, regarding lexical semantics, Hanks (2013) proposed that words don't have meaning, but meaning potential, which is realized according to their context. Nonetheless, from a very young age, infants start to learn concepts that enable them to make sense of their world and words that enable them to communicate about it, both in a way that supports mutual understanding with the community they are born into.

Some accounts of language posit a core language system that processes the phonological form and syntactical structure of language (Fedorenko, Ivanova; Regev, 2024; Jackendoff, 2002), which is translated into semantic meaning or conceptual knowledge, stored and processed in a separate cognitive system. In other accounts, the form-meaning mapping is viewed as the lexical unit (Bloom, 2000; Evans, 2009), and word meanings are an integral part of a distributed language network (Aliko *et al*., 2023; Huth *et al*., 2012). Although the latter view is adopted here, it is acknowledged that the question as to whether and how language and concepts interact and influence each other partly depends on how language is conceived (for a recent discussion of this point in relation to cognitive neuroscience, see van der Burght *et al*., 2023).

1. THEORIES OF CONCEPTUAL KNOWLEDGE

The storage and processing of conceptual knowledge have long been considered core functions of the human brain. However, the nature and development of conceptual knowledge are still debated (Antonucci; Alt, 2011; Barsalou, 2016; Gabora, Rosch; Aerts, 2008; Komatsu, 1992; Mareschal Mareschal, Quinn; Lea, 2010; Margolis; Laurence, 2015; Murphy, 2002). Here, a brief overview of theories of adult concepts is given, to situate the research into infant concept learning.

Within the "classical view" of concepts (Murphy, 2002), concepts are amodal symbols governed by definitional rules which are processed in distinct brain modules from those that process percepts, actions, and language (Fodor, 1983; Quillian, 1969; Pylyshyn, 1980). This view has been challenged on several fronts. Early research, focused on categorization, suggested that concepts were based on perceptual similarity rather than definitions, giving rise to prototype (Rosch, 1973, 1975; Rosch; Mervis, 1975) and exemplar (Medin; Schaffer, 1978) theories of concepts. Later theories emphasized the causal nature of concepts (Fodor; Pylyshyn, 2015; Johnson-Laird, 1983; Murphy; Medin,1985), arguing that concepts are used to reason about the world (for a comprehensive review see Murphy, 2002). These theories focused on core attributes of concepts, ignoring their contextually dependent structure (Barsalou, 1983; Tversky, 1977), although this was later incorporated within prototype theory (Rosch, 1999).

The focus on categorical structure also meant taxonomic knowledge was privileged above other world knowledge (Murphy, 2002). Nonetheless, the crucial role of thematic knowledge, knowledge gained through experience, in structuring concepts has also been highlighted (Estes *et al*., 2011; Fillmore, 1976, 1982; Lin; Murphy, 2001; Luria, 1976; Mirman, Landrigan and Britt, 2017; Schank; Abelson, 1977). Nelson (1988) suggested that thematic knowledge structures infant cognition, providing a foundation from which children can learn to categorize the world in terms of (superior) taxonomic structure, although more recent evidence suggests both types of knowledge coexist in adulthood (Estes *et al*., 2011; Sloutsky; Deng, 2019).

This focus on thematic knowledge is aligned with the increasingly influential view (Spivey, 2023) that concepts (and language) are embodied, that is, concepts are multimodal

representations grounded in perception, action, and bodily experiences (Barsalou, 2008, 2016; Rosch, 1999; Varela; Thompson; Rosch, 1991). These theories can be viewed as an extension of phenomenological theories (Gibson, 1979/1986; Maturana, 1970; Merleau-Ponty, 1945/2005) and theories that posited that mental imagery underlies much of cognition (Kosslyn; Thompson; Ganis, 2006; Paivio, 1986; see Palmiero *et al*., 2019, for a review). Piaget's influential work on child development can also be viewed as an embodied approach to cognition (Needham; Libertus, 2011). Embodied approaches provide a solution to the "symbol grounding problem" (Harnad, 1990), the argument that concepts and words must be connected to real-world referents to be meaningful (Searle, 1980). Within this framework, it has recently been suggested that embodied and situated influences on language acquisition should be differentiated (Reggin *et al*., 2023).

The earliest neurobiological evidence, from adults with brain damage to the temporal lobes, suggested that conceptual knowledge differs for animate and inanimate entities. Warrington and Shallice (1984) found a dissociation for both types of concepts, which they attributed to perceptual features being more important for animate concepts and functional information for inanimate concepts (see also Warrington; McCarthy, 1987). Later research suggests that taxonomic information is represented in the anterior temporal lobes (ATL; Bozeat *et al*., 2000; Blackett *et al*., 2022; Mirman, Landrigan; Britt, 2017). In contrast thematic information may be more widely distributed over brain regions according to the relevant sensorimotor structure of different concepts, as well as temporal regions (Blackett *et al*., 2022; Huth *et al*., 2012; Martin *et al*.,1995, 1996). This research has led to the idea that sensorimotor and affective information is important in structuring conceptual knowledge (Bauer; Just, 2019; Binder *et al*., 2016; Fernandino *et al*., 2022; Martin, 1998) and that the ATL form a hub that integrates this information with taxonomic knowledge (Damasio, 1989; Fernandino *et al*., 2016; Martin, 2016; Patterson, Nestor; Rogers, 2007; Rice, Lambon Ralph; Hoffman, 2015; Tranel, Damasio; Damasio, 1997; for an opposing view see Handjaras *et al*., 2016; Mahon; Caramazza, 2008).

2. EMBODIED CONCEPTUAL DEVELOPMENT

There is evidence to suggest that babies may be born with core knowledge or cognition (Carey, 2009), particularly the expectation that individual entities are cohesive (Spelke and Kinzler, 2007). Neonate cognitive skills could arise from evolved predispositions (including expectations of the niche babies are born into, see Odling-Smee, 2024) or *in utero* brain development, or reflect both processes (Finlay; Uchiyama, 2020). However, most conceptual development may be underpinned by humans' vast capabilities for learning from experience and from others (Csibra; Gergely, 2011; Laland; Seed, 2021). In line with this, embodied approaches to cognition are being increasingly incorporated with neuropsychological research into studies and theories of infant and child development (e.g., Goldin-Meadow, 2003; Needham; Libertus, 2011; Pexman, 2019; Wellsby; Pexman, 2014). Such theories highlight that children's neurocognitive development is nested within their developing sensorimotor capabilities which emerge in interaction with the constraints and affordances of their environment (Smith; Thelen, 2003). Despite the scarcity of research directly exploring whether embodied cognition approaches can account for conceptual development (Pexman, 2019), the available evidence supports this viewpoint.

Children's earliest concepts are thought to be derived from physical objects (through visual and tactile processing). Perceptual properties have been posited to underly the formation of concrete concepts (e.g., Antonucci; Alt, 2011; Mandler, 2004), with conceptual properties emerging later (Eimas; Quinn, 1994). In a series of experiments with 3- to 4-month olds, Eimas and Quinn (1994) showed that at this age infants can visually discriminate between animate entities based on perceptual features. Following habituation to pictures of horses the infants preferentially looked at pictures of giraffes or zebras rather than novel pictures of horses. However, the infants did not discriminate between cats and female lions, which were more similar perceptually. Likewise, Needham, Dueker, and Lockhead (2005) conducted a series of similar experiments with 4.5-month-old infants, in which they were shown patterned boxes adjacent to a cylinder in familiarization trials, followed by test trials in which a hand moved the cylinder away from a differently patterned box or moved both objects together. They found that infants looked longer on move-together test trials after familiarization, if shown at least three

varied but similar exemplar boxes, suggesting infants can individuate objects following experience with multiple exemplars.

Although the neurobiological evidence is limited, it supports the idea that infants start to recognize categories at a very early age. For example, Quinn, Westerlund, and Nelson (2006) used ERP recordings to examine 6-month-olds familiarization to images of cats and subsequent response to novel cats and dogs. They found a greater negative slow wave amplitude when viewing the first set of cats and the dogs over left occipital-parietal regions, indicating the novel cats were perceived as familiar; an increased negative central (Nc) component over the left-central scalp area to the novel dogs, suggesting increased attention; and a greater positive slow wave over right-central areas to the initial set of cats compared with all other animal sets, suggesting that the infants had recognized the greater perceptual difference between cats and dogs than cats and novel cats, but still not distinguished two separate categories of entities. In a follow-up study, Quinn *et al*. (2010) found similar results with images of two different dog breeds, confirming the presence of neural signatures of perceptual grouping and novelty recognition at 6 months. Such studies suggest that even very young infants have some ability to form perceptual object categories based on visual experience, which could provide a basis for the development of concepts.

Furthermore, Wilcox (1999) showed a gradual development in infants' ability to use perceptual features to reason about the number of individual objects involved in occlusion events. Specifically, at 4.5 months, infants demonstrated an ability to individuate objects according to shape (ball or box) and size, but they could not use pattern differences (dots versus stripes) until 7.5 months and color (a green versus a red ball) until 11.5 months. She hypothesized that these findings could be due to the earlier development of the dorsal (where) visual processing pathway compared to the ventral (what) pathway. In other words, infants may initially discriminate objects by perceiving shape and size information from motion, rather than from static form processing (see Peuskens *et al*., 2004, for evidence that shape is processed in both the dorsal and ventral visual pathways). More recently, Wilcox and colleagues (2012) have found support for this hypothesis using near-infrared spectroscopy (NIRS) in a similar occlusion event paradigm, finding activity in the parietal lobes of 3- to 5-month-old infants when the occluded objects were different shapes, indicating they processed shape in motion. These and

other studies suggest that form is prioritized in infants' early perceptual knowledge of objects, either in relation to motion or affordances for action (Wilcox; Biondi, 2015). Moreover, a longitudinal study of 52 infants aged from 3 to 24 months found that the amount and variability of early object exploration predicted later cognitive and language skills (Babik; Galloway; Lobo, 2022). Thus, infant studies support the view that conceptual development is grounded in experience.

3. THE LANGUAGE-READY BRAIN

Although infant word learning is also grounded in socially-mediated experience, the neonate brain evidences a neurobiological predisposition for language. Neuroimaging studies show that similar areas of the brain are activated by spoken language in newborns as in adults, namely areas within bilateral frontal, temporal, and parietal cortex, including the IFG (Broca's area) and the superior temporal gyrus (STG; Wernicke's area) adjacent to auditory cortical areas (Benavides-Varela *et al*., 2017; Dehaene-Lambertz; Kabdebon, 2020; Perani *et al*., 2011; for reviews in adults see Davies, 2016; Friederici; Singer, 2015; Turker *et al*., 2023). However, this could partly reflect *in utero* exposure to language coupled with the potential for learning being established by birth, possibly supported by a peak in synaptogenesis at birth (Bates *et al*., 2002). In a recent fNIRS study, René *et al*. (2025) exposed fetuses to stories in their native and a foreign language and again at birth, finding greater activation in fronto-temporal regions in neonates to the exposed stories than to an unexposed story in a different foreign language. In addition, Perani *et al*. (2011) found that the cortical areas activated by speech in neonates (1- to 3-days-old) showed reduced functional and structural connectivity within each hemisphere compared with adults, indicating that the language network develops later, after exposure to speech. Perani *et al*. (2011) compared activation to normal, hummed, and flattened speech, finding similar activity for hummed as normal speech, but not for flattened speech. These results suggest that the human brain may have an evolved capacity for processing phonological input but not for processing lexical semantics or syntax.

4. LEARNING TO ASSOCIATE WORDS AND OBJECTS

It is clear that exposure to language (typically adult talk) is the most important factor in early language development (Anderson *et al*., 2021; Bergelson *et al*., 2023). Moreover, social interaction is vital for language acquisition (Clark, E., 2023; Kuhl, 2010), which depends on shared intentionality (Tomasello, 2008). Children do not learn words merely by associating them with an object, but by associating them with the referent of the speaker's goals or intentions (Bloom, 2000). Indeed, very young infants may be more sensitive to the communicative intention of speakers than to the phonological sounds of language (Ferguson; Waxman, 2017). Thus, infants display an interest in language and an awareness of its purpose before they start to understand word meanings.

Infants and very young children are able to map words to their referents within a single exposure, known as fast mapping (Carey; Bartlett, 1978). However, it has been proposed that infants' first words may be better viewed as proto-words (associations between particular sounds and entities), with the word-concept mappings that characterize referential language use only starting to emerge around 18 months (Nazzi; Bertoncini, 2003). Even if infants' first word-object associations are perceptual rather than conceptual, research suggests they may start forming such associations as early as 6- to 9-months, as evidenced by preferential looking tasks (Bergelson; Swingley, 2012). However, early word-object associations may be unstable. In a study in which 24-month-olds were asked to associate a novel object with a novel label, Horst and Samuelson (2008) found they could often form the association, but retention over a 5-minute delay period fell to chance levels, when tested with two familiarized distractor objects. Similarly, in a study with 2-4-year-olds, Wilkinson, Ross, and Diamond (2003) found that most children could form two novel word-object mappings in presentation trials (they mapped the novel words onto the novel objects when presented with three familiar objects), but retention at test was much lower, particularly within the younger age group. Of note, half the children were shown the two novel objects in trials with three familiar objects (concurrent learning) and the other half were shown the second object in trials with the first novel object and two familiar ones (successive learning). Within the younger group, fewer children formed the mapping between the second novel object and word in the successive condition, but at test, retention was higher for the successive than the concurrent condition. This suggests that fast mapping improves with age, but also that younger

children who are able to form and remember novel word-object mappings only learn that a novel label goes with a novel word unless they are required to attend to features of the object and phonological word form in order to make the correct mapping. These studies indicate that infants are able to form word-object associations, but that this ability is limited and variable, and often does not lead to consolidation into a longer-term memory.

Neurological evidence supports these behavioral studies, suggesting young infants can recognize phonological word forms and objects. For example, in an ERP study with 3-month-olds, Friedrich and Friederici (2017) found that repeated presentations of word-image pairings led to detectable repetition effects for both images (a decreased negative central component indicative of visual habituation) and words (an increased N200-500 component indicative of facilitated word recognition, but not comprehension). However, they found no evidence of retention of the word-object pairings the next day. This suggests that at this very young age, infants' brains can detect regularities in sensory input, but it does not show infants can learn images and words.

Evidence with slightly older children also suggests that early word learning may be limited by memory, rather than language-specific factors. In a naturalistic fNIRS study, 32- and 54-month-olds were taught novel labels for sets of unfamiliar objects during short play sessions with their female caregiver, then tested on their ability to remember the object names (Mosteller; Wijeakumar; Wass, 2025). Individual learning outcomes were related to prior word knowledge, but not to the number of times they or their caregiver named the objects during play. The fNIRS data showed increased activation within the right inferior parietal lobe (specifically the supramarginal gyrus) when caregivers named the objects during play and reduced activation in the right posterior temporal cortex for learned compared to unlearned object names. This suggests that word learning is more successful when the word-object mapping is less effortful. In addition, in a study with 4-year-old children, Ekerdt *et al*. (2020) showed that fractional anisotropy of white matter tracts in the left temporal lobe was correlated with fast mapping skills in word learning, whereas repeated word learning training was associated with structural white matter changes (plasticity) in areas associated with working memory and attention rather than language processing (dorsal precentral gyrus, including the corpus callosum).

In sum, infants start learning about things in the world before they start learning the words that label them. This early ability to use perceptual, situated experience may underly their fast mapping of words to objects as language skills emerge, albeit constrained by memory capacity. This grounding of language may be what allows infants to overcome the relatively sparse exposure to individual words as they start learning language (Clerkin; Smith, 2022).

5. LABELING CONCEPTS

Some concepts are learned prelinguistically (e.g., Clerkin; Smith, 2022; Mandler, 2004) and there is also evidence that animals may have some concepts (Fitch, 2020). However, language may influence conceptual knowledge (e.g., Pavlenko, 2014; but see Fedorenko; Piantadosi; Gibson, 2024), including in infant learning (Borovsky; Elman, 2006; Ferguson; Waxman, 2017). This claim entails that infants understand that language can be used to refer to the world. Studies suggest that this understanding develops very quickly after birth. For example, a study with 4-month-old infants by Marno *et al*. (2015) found that a combination of speech and congruent gaze cues reduced the time taken to orientate attention to objects. This suggests that infants can use changes in eye gaze to understand when speech refers to something in the world before they can understand the content of speech acts, indicating that speech has the potential to support early concept learning even before infants understand word meanings.

In the earliest study into language effects on infant category learning, Waxman and Markow (1995) found that providing word labels during familiarization with toy instances of particular kinds (such as animals or vehicles) could help 1-year-old infants distinguish between a novel toy from the same superordinate category and a novel toy from a different category in a following test phase (as evidenced by longer looking times at the toy from a different category). In one of the most recent updates of this study, LaTourrette, Chan, and Waxman (2023) investigated the effect on immediate test recognition between labelling category members (e.g., different toy animals) with the same or unique verbal labels during familiarization with four exemplars. They found that unique labels helped 12-month-olds distinguish the familiarized toys from novel exemplars of the same category. They found a similar effect in 7-month-olds, although their recognition memory was limited to the most recently shown familiar exemplar (shown first at test).

Similarly, in a study in which 10-month-olds were shown images of exemplars of two perceptually distinct kinds of novel toy, Sučević, Althaus, and Plunkett (2021) found that hearing different labels could support categorization, whereas viewing two different types of motion (rocking or jumping) had a much more limited effect (although it did increase attention). Such studies suggest that even at the very earliest stages of language acquisition, infants are able to use the information provided by word labels to help them learn about objects. In contrast, in a categorization study using novel (unusual) objects, 14-month-old infants were able to use displays of the function of objects to form categories but not linguistic labels, whereas at 18 months, infants could learn similarly from function and naming (Booth; Waxman, 2002), suggesting that at very early stages of language acquisition, words may only aid categorization in the presence of previous conceptual knowledge. Therefore, at these early stages of learning about concepts and words, this facilitation may be an emerging rather than a robust phenomenon, in line with dynamical accounts of development and learning (Smith; Thelen, 2003).

Neurobiological support for these behavioral studies was provided by a study with 1-year-old infants by Gliga, Volein, and Csibra (2010). They found increased gamma-band activity in occipito-temporal areas in the left hemisphere when infants viewed images of familiar and novel objects for which they knew or had been taught language labels compared with objects for which they had no verbal label, suggesting that verbal labels alter visual processing in infants, as in adults. This suggests that lexical semantics may facilitate infants' top-down processing of sensory stimuli by modifying either perceptual or attentional processes.

As emphasized by Waxman and Markow (1995), word labels may help infants group category exemplars together when the perceptual similarity between them is insufficient for infants to recognize them as a set. Thus, language can assist but does not replace sensorimotor learning. In an eye-tracking experiment with 12-month-old infants, Althaus and Plunkett (2016) showed that labels have a qualitative effect on 12-month-old infants' attention to features of novel objects, inducing them to focus more on commonalities between exemplars. Likewise, in a study with 10-month-old infants, Althaus and Westermann (2016) found that labels help infants to recognize category boundaries. This implies that words may help infants form categorical representations, but also leaves open the possibility that when perceptual information is a reliable

source to distinguish between different categories, language may interfere with this process, promoting a false integration (Sloutsky, 2010).

One possibility is that coordinate category members are typically learned through direct experience, either without language (Jardak; Byers-Heinlein, 2019) or with language playing a later role in acquisition (Nelson, 1988). However, superordinate categories are most likely to be learned later and explicitly, via language (Renoult *et al*., 2012; see also Collins; Loftus,1975). Explicit instruction and literacy skills may be needed to support taxonomic knowledge as such knowledge is more abstract than knowledge gained through experience (Luria, 1976). Plunkett *et al*. (2022) showed that priming effects in 24-month-olds are found when familiar words are associatively related (through language or situated associations) but not when they only share a taxonomic (category-based) relation. In a study with older children (4- to 5-years-olds) and adults, Unger, Savic, and Sloutsky (2020) compared priming and interference between word-pairs and word-picture pairs that were taxonomically related or associated through frequent linguistic co-occurrence, finding that children's performance showed a sensitivity to word co-occurrence but not to taxonomic relations, whereas adult performance was sensitive to both. This suggests that infants and children use associations between words and words and their referents to form semantic links before they use taxonomic category information and that taxonomic information supplements but does not replace associations (Sloutsky, 2010). Thus, language, perception, action, and cognition may all be intertwined in development and throughout the lifespan.

6. CONCLUSIONS

At least the first concepts and words that infants learn are grounded in experience as they perceive and act on the world supported by other social actors (caregivers). This developmental evidence is crucial support for embodied approaches to cognition (Sheya; Smith, 2019), although few infant studies have been explicitly derived to test embodied theories or have used it as a framework (Needham; Libertus, 2011; Wellsby; Pexman, 2014). More research is needed into the reciprocal influences of cognition, action, and perception throughout infant development, as well as how experience changes the developing brain. This will further our understanding of how perception, action, and cognition remain intertwined in childhood (Kalénine; Bonthoux, 2008)

and even in adulthood (Buzsáki, 2019; Frith, 2007; Pessoa, 2022). Despite the importance of categorical knowledge, more studies are needed into the continued role of situational or experiential knowledge in structuring concepts throughout the life span (Estes *et al*., 2011; Fernandino *et al*., 2022; Luria, 1976; Mirman; Graziano, 2012; Savic, Thierry; Kovic, 2020; Sloutsky; Deng, 2019). Neural evidence supports a dissociation of both types of conceptual structure (Blackett *et al*., 2022; Schwartz *et al*., 2011), yet how this impacts cognition is still unknown.

Once infants start mapping words to their referents, language also provides a means for learning about the world and acting on it. Language can help direct perception and coordinate action, suggesting the possibility that linguistic experience can also play a role in grounding cognition (Borghi *et al*., 2019). There are various theories of the role of language in structuring or bootstrapping abstract concepts (Carey, 2009; Clark, A., 2006; Dove, 2020) as well as how word labels facilitate categorization (Lupyan; Lewis, 2019). If adults (Meyer *et al*., (2007) and even infants (Mani; Plunkett, 2010) unconsciously label the world as they interact with it, it raises the possibility that as soon as babies start to learn language, lexical knowledge forms an integral part of conceptual structure (Humboldt,1836/1999; Vigliocco *et al*., 2004), both for abstract and concrete concepts. If this idea is correct, it has profound implications for theories of language and cognition across the lifespan.

ADDITIONAL INFORMATION

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Data sharing is not applicable to this article, as no new data were created or analyzed in this study.

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