Is core knowledge a natural subdivision of infant cognition?

Article *in* Behavioral and Brain Sciences · June 2024

DOI: 10.1017/S0140525X23003229

Julia Conti
Carnegie Mellon University

Abhishek Dedhe
Carnegie Mellon University

Lauren S Aulet
Carnegie Mellon University

Behavioral and Brain Sciences

Article contents

Is core knowledge a natural subdivision of infant cognition?

Published online by Cambridge University Press: **27 June 2024**

Caroline M. Kaicher, Julia J. Conti, Abhishek M. Dedhe, Lauren S. Aulet and Jessica F. Cantlon

Commentary Related commentaries Metrics

Abstract

We examine Spelke's core knowledge taxonomy and test its boundaries. We ask whether Spelke's core knowledge is a distinct *type* of cognition in the sense that the cognitive processes it includes and excludes are biologically and mechanically coherent.

Type	Open Peer Commentary
Information	Behavioral and Brain Sciences, Volume 47, 2024, e133 DOI: https://doi.org/10.1017/S0140525X23003229 Check for updates
Copyright	Copyright © The Author(s), 2024. Published by Cambridge University Press

Spelke's central thesis classifies infant knowledge into the following distinct core knowledge systems: Objects, places, number, forms, agents, and social beings. These systems apply to specific domains of entities in the world and capture specific properties of those entities. They share many features – perhaps the most critical being that they are ancient, automatic, center on abstract concepts, and emerge early in life. Spelke characterizes these systems as innate, invariant over development, impervious to explicit beliefs, and dependent on attention, with a primary function of supporting learning and operating (in part) through mental stimulation. Thus, core knowledge systems are defined not only by their functional role in human cognition but also by characteristics of the mechanisms supporting them. Spelke's core knowledge taxonomy provides a framework for understanding the evolutionary and developmental origins of human knowledge, including the foundations of complex cognition.

However, we question the ability of Spelke's core knowledge taxonomy to "carve nature at its joints." Testing the boundaries of Spelke's core knowledge framework is important because it helps refine the theory, enabling more precise predictions about the emergence and progression of infant cognition. Here, we ask whether Spelke's collection of core knowledge domains represent a meaningfully distinct *type* of cognition. Infants have several other cognitive functions that share characteristics with the core domains in that they are ancient, automatic, early-emerging, and abstract cognitive processes that are integral to infants' information processing, and equally essential for explaining what they know. We describe three examples – categorical perception, referential understanding, and algebraic rule learning – to demonstrate this point, raising the question: Is Spelke's "core knowledge" a natural subdivision of infant cognition?

Spelke uses the common characteristics shared by object, place, number, form, agent, and social systems to argue that core knowledge is a distinct cognitive *type*. Specifically, she claims that all the shared characteristics of the core domains "go together," and that, "any ancient, abstract conceptual system that has some of these properties is likely to have all of them" (Spelke, 2022, p. 198). Critically, Spelke states that core knowledge systems focus on "the problem of understanding what the sensed world consists of: what entities inhabit it, how those entities behave, and why they do what they do" (Spelke, 2022, p. 36). But, given the criteria, which mechanisms of infant cognition are *not* core knowledge – and why not?

Here we argue that there is no sharp boundary between Spelke's core knowledge and the rest of infant cognition by showing how three fundamental cognitive processes – categorical perception, referential understanding, and algebraic rule learning – are not only automatic, unconscious, ancient, and abstract, but also support knowledge in infants and are essential to their understanding of the perceptual world.

Categorical perception: Infants display categorical perception, or the propensity to assign discrete boundaries among stimuli varying along a continuum. This process is demonstrated when perceptual discriminations are easier for items belonging to different categories, and more difficult for items belonging to the same category, even when their physical differences are objectively equal (Goldstone & Hendrickson, 2010). The most prominent example of this is speech perception, during which we perceive phonemes that are abstracted from the pure acoustic properties of the signal. This process is automatic (Kasai et al., 2003), and is demonstrated in infants as young as 1 month old (Eimas, Siqueland, Jusczyk, & Vigorito, 1971). This ability is not uniquely human – macaques exhibit the same phoneme boundary effect as 1-month-old infants (Kuhl & Padden, 1982), European starlings can learn vowel sound categories (Kluender, Lotto, Holt, & Bloedel, 1998), and chinchillas detect changes along phoneme boundaries in particular (Kuhl, 1981). Additionally, the neural basis of this ability is shared between infants and adults (Dehaene-Lambertz & Gliga, 2004), and also among humans and non-human primates (Ley et al., 2012). Beyond speech, 2-month-old infants categorically perceive some non-speech sounds (Jusczyk, Rosner, Cutting, Foard, & Smith, 1977), 7-month-old infants display categorical perception of facial expressions of emotion (Kotsoni, de Haan, & Johnson, 2001), and 4-month-olds categorically perceive color (Franklin et al., 2008). Categorical perception of color has also been shown in goldfish (Goldman, Lanson, & Brown, 1990) and zebra finches (Zipple et al., 2019).

Categorical perception makes items that are meaningfully different *more* distinct, and makes those that are meaningfully similar *more* similar. This helps infants eliminate unnecessary information and allows them to more efficiently represent the stimuli around them (Oakes & Madole, 2003). This capacity provides the "building blocks" for higher-order categories (Harnad, 1987), which is not only critical for learning language (Werker & Lalonde, 1988), but it may also be a basis for social categorization in infants (Liberman, Woodward, & Kinzler, 2017). Thus, the propensity to create discrete category representations is a core aspect of infant cognition that is abstract, ancient, early-emerging, automatic, and supports learning.

Referential understanding: Referential understanding refers to the ability to understand that communicative signals such as words and pointing are linked to something concrete in the world, and to use such signals to imply intended referents (Wynne & Udell, 2013). Infants as young as 3 months old demonstrate this by using words to help them categorize objects (Ferry, Hespos, & Waxman, 2010). At 1 year old, infants understand the referential nature of deictic gestures (Gliga & Csibra, 2009) and begin to utilize pointing (Tomasello, Carpenter, & Liszkowski, 2007). Referential understanding is also automatic, as demonstrated every time we use language. The ability to match symbols or gestures to referents is also present in dogs (Kaminski, Call, & Fischer, 2004), dolphins (Herman, Richards, & Wolz, 1984), and apes (Savage-Rumbaugh, Shanker, & Taylor, 1998). Spelke argues that our propensity to use symbols is rooted in human-specific language abilities, but since this capacity is shared between species, it may be more primitive. In fact, linking labels to referents can be considered an associative process during which children use space/object and space/

word associations to link words to objects (Samuelson, Smith, Perry, & Spencer, 2011). Associative processes such as this are abstract (Delamater, Desouza, Rivkin, & Derman, 2014) and are present in a variety of non-human animals (Rescorla & Holland, 1982).

Referential understanding is key for word learning in infants (Gentner & Boroditsky, 2001), and in their second year they begin to utilize the non-arbitrary referential actions of others (i.e., looking and pointing) to establish arbitrary referential relationships, such as mapping words onto objects (Baldwin, 1993). Additionally, 12-month-old infants rely on referential cues to connect others' emotional messages with novel objects (Moses, Baldwin, Rosicky, & Tidball, 2001). Thus, referential understanding is not only abstract, early-emerging, ancient, and automatic, but it also plays an important role in infants' learning about the world around them.

Algebraic rule learning: Algebraic rule learning requires one to detect relations between entities, and is characterized by an ability to generalize patterns to novel items (Dehaene, Meyniel, Wacongne, Wang, & Pallier, 2015). Infants demonstrate this through their remarkable ability to extract rules from visual and auditory input. For example, 3-month-olds can generalize same/different relations among arrays of toys (Anderson, Chang, Hespos, & Gentner, 2018) and 4-month-olds can do so with geometric shapes (Addyman & Mareschal, 2010). Additionally, newborns can discriminate spoken syllable patterns (Gervain, Macagno, Cogoi, Peña, & Mehler, 2008). Our detection of algebraic rules is also an automatic and unconscious process (Dehaene et al., 2015; Miller, 1967). Kanzi the chimpanzee demonstrated the ability to understand word order grammatical rules (Schoenemann, 2022), dolphins display key elements of syntax (Kako, 1999), and crows and monkeys can even generate recursive sequences (Ferrigno, Cheyette, Piantadosi, & Cantlon, 2020; Liao, Brecht, Johnston, & Nieder, 2022). In addition, macaques can learn context-free grammars based on embedded spatial sequences (Ferrigno, 2022; Jiang et al., 2018), demonstrating an evolutionarily conserved propensity for algebraic rule learning.

Infants' rule learning abilities are essential to the development of complex capacities such as language. For instance, 4-month-olds can detect non-adjacent grammatical dependencies in a novel language after only one learning session (Friederici, Mueller, & Oberecker, 2011), and 17-month-olds can segment words in fluent speech based on non-adjacent dependencies using statistical learning (Frost et al., 2020). Infants' rule-learning abilities also help them learn the “grammar” of music (McMullen & Saffran, 2004). Thus, abundant evidence demonstrates that algebraic rule learning is an abstract, early-emerging, automatic, unconscious, and ancient aspect of infant knowledge, supporting learning in multiple domains (Rabagliati, Ferguson, & Lew-Williams, 2019).

Perhaps what makes the core domains in Spelke's theory distinct is that they "operate on a limited domain of entities" and "capture only a limited subset of properties that our perceptual systems deliver" (Spelke, 2022, p. 190). However, we question whether Spelke's core domains are more selective, rigid, or filtered than other systems. For instance, knowledge of number can be used with any discrete set of things or events, and adapts to new, evolutionarily recent information such as digits and verbal counting. Numerical information automatically interacts with perceptual and semantic information from disparate domains during development (e.g., Gebuis, Cohen Kadosh, De Haan, & Henik, 2009). Ferrigno, Jara-Ettinger, Piantadosi, and Cantlon (2017) showed that when both numerical and surface area information is available for approximate magnitude discrimination, numerical biases are uniquely enhanced in humans compared to non-human primates. Additionally, they found that within the Tsimane', a non-industrialized group in Bolivia, adults who have learned to count display a greater number bias than those who have not. Spelke herself even discusses how Mundurucu children and adults who have been exposed to formal education have more precise numerical representations than those who have not (Piazza, Pica, Izard, Spelke, & Dehaene, 2013). Spelke uses this evidence to show that the core number system supports learning of the symbolic number system, but it also shows that the core number system can be penetrated by novel domains and inputs. Thus, the number system may not be as independent, rigid, or limited as it is made out to be. Similarly, the limitations of the "core" systems, such as the numerical system, are not greater than the biases and constraints on other informational systems such as categorical perception, referential understanding, and rule learning. All mechanisms have their own unique cognitive signatures and constraints for abstracting information across diverse entities while adapting to novel inputs and problems.

Mechanisms that are (perhaps erroneously) considered more "general purpose" than the core domains also exhibit biases and constraints on processing. This is even the case for reinforcement learning, in which avoidance responses to different reinforcers (induced nausea or shock) are more readily associated with certain cues (gustatory and audiovisual, respectively) than others in rats (Garcia & Koelling, 1966). This bias is present in humans, as shown through the privileged role of nausea in the acquisition of food dislikes (Pelchat & Rozin, 1982). Thus, deep information processing biases are present in this "general" mechanism and influence learning in humans. Our three purportedly general-purpose mechanisms also display innate biases and are subject to information constraints and filters. For instance, rule learning, like the number system, has capacity limits – just as larger numerical differences are easier to discriminate than smaller ones, shorter range dependencies are easier to learn than longer ones (Futrell, Mahowald, & Gibson, 2015). For referential understanding, children display specific biases, such as the whole-object, taxonomic, and mutual exclusivity assumptions, that constrain how they map words onto referents (Markman, 1991). Additionally, information processing through categorical perception is constrained so that objective similarities between stimuli are filtered based on useful category boundaries (Goldstone & Hendrickson, 2010). Category formation can also be constrained by the number of exemplars, their variability, and their similarity (Needham, Dueker, & Lockhead, 2005).

Thus, categorical perception, referential understanding, and algebraic rule learning are three examples of key components of infant cognition – things that babies "know" and that are integral to their understanding of the world. These processes exhibit innate biases and are subject to information constraints, abstraction, and filters similar to Spelke's core knowledge domains. The range of infant abilities that are early-emerging, abstract, automatic, ancient, and *not* considered core knowledge indicates that infant knowledge emerges independently of the purported specificity of its domain. In this sense, the boundaries of core knowledge set by Spelke are not biologically and mechanically coherent, and are displaced from the evolutionary and developmental origins of infant cognition and the knowledge it generates. The disconnection between well-known evolved cognitive functions and Spelke's lens limits the explanatory and predictive power of "core knowledge" as a taxonomy – if the boundaries of core knowledge arbitrarily exclude key forms of infant cognition, then the framework cannot anticipate what babies naturally know.

Financial support

This work was supported by the National Institute of Child Health and Human Development (JFC, grant number R01HD107715); and National Science Foundation (JFC, grant number 2148343).

Competing interest

None.

References

Addyman, C., & Mareschal, D. (2010). The perceptual origins of the abstract same/different concept in human infants. Animal Cognition, 13, 817–833. https://doi.org/10.1007/s10071-010-0330-0 CrossRef Google Scholar PubMed

Anderson, E. M., Chang, Y., Hespos, S., & Gentner, D. (2018). Comparison within pairs promotes analogical abstraction in three-month-olds. Cognition, 176, 74–86. https://doi.org/10.1016/

j.cognition.2018.03.008 CrossRef Google Scholar PubMed

Baldwin, D. A. (1993). Early referential understanding: Infants' ability to recognize referential acts for what they are. Developmental Psychology, 29(5), 832. https://doi.org/10.1037/0012-1649.29.5.832 CrossRef Google Scholar

Dehaene, S., Meyniel, F., Wacongne, C., Wang, L., & Pallier, C. (2015). The neural representation of sequences: From transition probabilities to algebraic patterns and linguistic trees. Neuron, 88(1), 2–19. https://doi.org/10.1016/j.neuron.2015.09.019 CrossRef Google Scholar PubMed

Dehaene-Lambertz, G., & Gliga, T. (2004). Common neural basis for phoneme processing in infants and adults. Journal of Cognitive Neuroscience, 16(8), 1375–1387. https://doi.org/10.1162/0898929042304714 CrossRef Google Scholar

Delamater, A. R., Desouza, A., Rivkin, Y., & Derman, R. (2014). Associative and temporal processes: A dual process approach. Behavioural Processes, 101, 38–48. https://doi.org/10.1016/j.beproc.2013.09.004 CrossRef Google Scholar PubMed

Eimas, P. D., Siqueland, E. R., Jusczyk, P., & Vigorito, J. (1971). Speech perception in infants. Science, 171(3968), 303–306. https://doi.org/10.1126/science.171.3968.303 CrossRef Google Scholar PubMed

Ferrigno, S. (2022). Sequencing, artificial grammar, and recursion in primates. In Shwartz, B. L., & Beran, M. J. (Eds.), Primate cognitive studies (pp. 260–290). Cambridge University Press. CrossRef Google Scholar

Ferrigno, S., Cheyette, S. J., Piantadosi, S. T., & Cantlon, J. F. (2020). Recursive sequence generation in monkeys, children, US adults, and native Amazonians. Science Advances, 6(26), eaaz1002. https://doi.org/10.1126/sciadv.aaz1002 CrossRef Google Scholar PubMed

Ferrigno, S., Jara-Ettinger, J., Piantadosi, S. T., & Cantlon, J. F. (2017). Universal and uniquely human factors in spontaneous number perception. Nature Communications, 8(1), 13968. https://doi.org/10.1038/ncomms13968 CrossRef Google Scholar PubMed

Ferry, A. L., Hespos, S. J., & Waxman, S. R. (2010). Categorization in 3- and 4-month-old infants: An advantage of words over tones. Child Development, 81(2), 472–479. https://doi.org/10.1111/j.1467-8624.2009.01408.x CrossRef Google Scholar PubMed

Franklin, A., Drivonikou, G. V., Bevis, L., Davies, I. R., Kay, P., & Regier, T. (2008). Categorical perception of color is lateralized to the right hemisphere in infants, but to the left hemisphere in adults. Proceedings of the National

Academy of Sciences, 105(9), 3221–3225. https://doi.org/10.1073/pnas.0712286105 CrossRef Google Scholar

Friederici, A. D., Mueller, J. L., & Oberecker, R. (2011). Precursors to natural grammar learning: Preliminary evidence from 4-month-old infants. PLoS ONE, 6(3), e17920. https://doi.org/10.1371/journal.pone.0017920 CrossRef Google Scholar PubMed

Frost, R. L., Jessop, A., Durrant, S., Peter, M. S., Bidgood, A., Pine, J. M., … Monaghan, P. (2020). Non-adjacent dependency learning in infancy, and its link to language development. Cognitive Psychology, 120, 101291. https://doi.org/10.1016/j.cogpsych.2020.101291 CrossRef Google Scholar PubMed

Futrell, R., Mahowald, K., & Gibson, E. (2015). Large-scale evidence of dependency length minimization in 37 languages. Proceedings of the National Academy of Sciences, 112(33), 10336–10341. https://doi.org/10.1073/pnas.1502134112 CrossRef Google Scholar PubMed

Garcia, J., & Koelling, R. A. (1966). Relation of cue to consequence in avoidance learning. Psychonomic Science, 4, 123–124. https://doi.org/10.3758/BF03342209 CrossRef Google Scholar

Gebuis, T., Cohen Kadosh, R., De Haan, E., & Henik, A. (2009). Automatic quantity processing in 5-year olds and adults. Cognitive Processing, 10, 133–142. https://doi.org/10.1007/s10339-008-0219-x CrossRef Google Scholar PubMed

Gentner, D., & Boroditsky, L. (2001). Individuation, relativity, and early word learning. Language Acquisition and Conceptual Development, 3, 215–256. CrossRef Google Scholar

Gervain, J., Macagno, F., Cogoi, S., Peña, M., & Mehler, J. (2008). The neonate brain detects speech structure. Proceedings of the National Academy of Sciences, 105(37), 14222–14227. https://doi.org/10.1073/pnas.0806530105 CrossRef Google Scholar PubMed

Gliga, T., & Csibra, G. (2009). One-year-old infants appreciate the referential nature of deictic gestures and words. Psychological Science, 20(3), 347–353. https://doi.org/10.1111/j.1467-9280.2009.02295.x CrossRef Google Scholar PubMed

Goldman, M., Lanson, R., & Brown, G. G. (1990). Wavelength categorization by goldfish (*Carassius auratus*). International Journal of Comparative Psychology, 4(3). https://doi.org/10.46867/C4JS4X CrossRef Google Scholar

Goldstone, R. L., & Hendrickson, A. T. (2010). Categorical perception. Wiley Interdisciplinary Reviews: Cognitive Science, 1(1), 69–78. https://doi.org/10.1002/wcs.26 Google Scholar PubMed

Harnad, S. (1987). Psychophysical and cognitive aspects of categorical perception: A critical overview. In Harnad, S. (Ed.), Categorical perception: The groundwork of cognition (pp. 1–25). Cambridge University Press. Google Scholar

Herman, L. M., Richards, D. G., & Wolz, J. P. (1984). Comprehension of sentences by bottlenosed dolphins. Cognition, 16(2), 129–219. https://doi.org/10.1016/0010-0277(84)90003-9 CrossRef Google Scholar PubMed

Jiang, X., Long, T., Cao, W., Li, J., Dehaene, S., & Wang, L. (2018). Production of supra-regular spatial sequences by macaque monkeys. Current Biology, 28(12), 1851–1859. https://doi.org/10.1016/j.cub.2018.04.047 CrossRef Google Scholar PubMed

Jusczyk, P. W., Rosner, B. S., Cutting, J. E., Foard, C. F., & Smith, L. B. (1977). Categorical perception of nonspeech sounds by 2-month-old infants. Perception & Psychophysics, 21, 50–54. https://doi.org/10.3758/BF03199467 CrossRef Google Scholar

Kako, E. (1999). Elements of syntax in the systems of three language-trained animals. Animal Learning & Behavior, 27, 1–14. https://doi.org/10.3758/BF03199424 CrossRef Google Scholar

Kaminski, J., Call, J., & Fischer, J. (2004). Word learning in a domestic dog: Evidence for “fast mapping”. Science, 304(5677), 1682–1683. https://doi.org/10.1126/science.1097859 CrossRef Google Scholar

Kasai, K., Yamada, H., Kamio, S., Nakagome, K., Iwanami, A., Fukuda, M., … Kato, N. (2003). Neuromagnetic correlates of impaired automatic categorical perception of speech sounds in schizophrenia. Schizophrenia Research, 59(2–3), 159–172. https://doi.org/10.1016/S0920-9964(01)00382-6 CrossRef Google Scholar PubMed

Kluender, K. R., Lotto, A. J., Holt, L. L., & Bloedel, S. L. (1998). Role of experience for language-specific functional mappings of vowel sounds. The Journal of the Acoustical Society of America, 104(6), 3568–3582. https://doi.org/10.1121/1.423939 CrossRef Google Scholar PubMed

Kotsoni, E., de Haan, M., & Johnson, M. H. (2001). Categorical perception of facial expressions by 7-month-old infants. Perception, 30(9), 1115–1125. https://doi.org/10.1068/p3155 CrossRef Google Scholar PubMed

Kuhl, P. K. (1981). Discrimination of speech by nonhuman animals: Basic auditory sensitivities conducive to the perception of speech-sound categories. The Journal of the Acoustical Society of America, 70(2), 340–349. https://doi.org/10.1121/1.386782 CrossRef Google Scholar

Kuhl, P. K., & Padden, D. M. (1982). Enhanced discriminability at the phonetic boundaries for the voicing feature in macaques. Perception & Psychophysics, 32(6), 542–550. https://doi.org/10.3758/BF03204208 CrossRef Google Scholar PubMed

Ley, A., Vroomen, J., Hausfeld, L., Valente, G., De Weerd, P., & Formisano, E. (2012). Learning of new sound categories shapes neural response patterns in human auditory cortex. Journal of Neuroscience, 32(38), 13273–13280. https://doi.org/10.1523/JNEUROSCI.0584-12.2012 CrossRef Google Scholar PubMed

Liao, D. A., Brecht, K. F., Johnston, M., & Nieder, A. (2022). Recursive sequence generation in crows. Science Advances, 8(44), eabq3356. https://doi.org/10.1126/sciadv.abq3356 CrossRef Google Scholar PubMed

Liberman, Z., Woodward, A. L., & Kinzler, K. D. (2017). The origins of social categorization. Trends in Cognitive Sciences, 21(7), 556–568. https://doi.org/10.1016/j.tics.2017.04.004 CrossRef Google Scholar PubMed

Markman, E. M. (1991). The whole-object, taxonomic, and mutual exclusivity assumptions as initial constraints on word meanings. In Gelman, S. A., & Byrnes, J. P. (Eds.), Perspectives on language and thought: Interrelations in development (pp. 72–106). Cambridge University Press. https://doi.org/10.1017/CBO9780511983689.004 CrossRef Google Scholar

McMullen, E., & Saffran, J. R. (2004). Music and language: A developmental comparison. Music Perception, 21(3), 289–311. https://doi.org/10.1525/mp.2004.21.3.289 CrossRef Google Scholar

Miller, G. A. (1967). The psychology of communication. Human Resource Management, 6(3), 43. Google Scholar

Moses, L. J., Baldwin, D. A., Rosicky, J. G., & Tidball, G. (2001). Evidence for referential understanding in the emotions domain at twelve and eighteen months. Child Development, 72(3), 718–735. https://doi.org/10.1111/1467-8624.00311 CrossRef Google Scholar PubMed

Needham, A., Dueker, G., & Lockhead, G. (2005). Infants' formation and use of categories to segregate objects. Cognition, 94(3), 215–240. https://doi.org/10.1016/j.cognition.2004.02.002 CrossRef Google Scholar PubMed

Oakes, L. M., & Madole, K. L. (2003). Principles of developmental change in infants' category formation. In Rakison, D. H., & Oakes, L. M. (Eds.), Early category and concept development: Making sense of the blooming, buzzing confusion (pp. 132–158). Oxford University Press. CrossRef Google Scholar

Pelchat, M. L., & Rozin, P. (1982). The special role of nausea in the acquisition of food dislikes by humans. Appetite, 3(4), 341–351. https://doi.org/10.1016/S0195-6663(82)80052-4 CrossRef Google Scholar PubMed

Piazza, M., Pica, P., Izard, V., Spelke, E. S., & Dehaene, S. (2013). Education enhances the acuity of the nonverbal approximate number system. Psychological Science, 24(6), 1037–1043. https://doi.org/10.1177/0956797612464057 CrossRef Google Scholar PubMed

Rabagliati, H., Ferguson, B., & Lew-Williams, C. (2019). The profile of abstract rule learning in infancy: Meta-analytic and experimental evidence. Developmental Science, 22(1), e12704. https://doi.org/10.1111/desc.12704 CrossRef Google Scholar PubMed

Rescorla, R. A., & Holland, P. C. (1982). Behavioral studies of associative learning in animals. Annual Review of Psychology, 33(1), 265–308. CrossRef Google Scholar

Samuelson, L. K., Smith, L. B., Perry, L. K., & Spencer, J. P. (2011). Grounding word learning in space. PLoS ONE, 6(12), e28095. https://doi.org/10.1371/journal.pone.0028095 CrossRef Google Scholar PubMed

Savage-Rumbaugh, E. S., Shanker, S., & Taylor, T. J. (1998). Apes, language, and the human mind. Oxford University Press. CrossRef Google Scholar

Schoenemann, P. T. (2022). Evidence of grammatical knowledge in apes: An analysis of Kanzi's performance on reversible sentences. Frontiers in Psychology, 13, 885605. https://doi.org/10.3389/fpsyg.2022.885605 CrossRef Google Scholar PubMed

Spelke, E. S. (2022). What babies know: Core knowledge and composition volume 1 (Vol. 1). Oxford University Press. CrossRef Google Scholar

Tomasello, M., Carpenter, M., & Liszkowski, U. (2007). A new look at infant pointing. Child Development, 78(3), 705–722. https://doi.org/10.1111/j.1467-8624.2007.01025.x CrossRef Google Scholar

Werker, J. F., & Lalonde, C. E. (1988). Cross-language speech perception: Initial capabilities and developmental change. Developmental Psychology, 24(5), 672. https://doi.org/10.1037/0012-1649.24.5.672 CrossRef Google Scholar

Wynne, C. D., & Udell, M. A. (2013). Animal cognition: Evolution, behavior and cognition. Bloomsbury Publishing. CrossRef Google Scholar

Zipple, M. N., Caves, E. M., Green, P. A., Peters, S., Johnsen, S., & Nowicki, S. (2019). Categorical colour perception occurs in both signalling and non-signalling colour ranges in a songbird. Proceedings of the Royal Society B: Biological Sciences, 286(1903), 20190524. https://doi.org/10.1098/rspb.2019.0524 Google Scholar

In response to: **Precis of What Babies Know**

Related commentaries (25) Author response

Related content

AI-generated results: by UNSILO

Article

Innateness, autonomy, universality? Neurobiological approaches to language
Ralph-Axel Müller
Behavioral and Brain Sciences
Published online: 4 February 2010

Article

Pluripotentiality, epigenesis, and language acquisition
Bob Jacobs and Lori Larsen
Behavioral and Brain Sciences
Published online: 4 February 2010

Article

Neurobiology and linguistics are not yet unifiable
David Poeppel
Behavioral and Brain Sciences
Published online: 4 February 2010

Article

Neuroanatomical structures and segregated circuits
Philip Lieberman
Behavioral and Brain Sciences
Published online: 4 February 2010

Article

Innateness, autonomy, universality, and the neurobiology of regular and irregular inflectional morphology
David Kemmerer
Behavioral and Brain Sciences
Published online: 4 February 2010

Article

Müller's conclusions and linguistic research
Frederick J. Newmeyer
Behavioral and Brain Sciences
Published online: 4 February 2010

Article

Sign language and the brain: Apes, apraxia, and aphasia
David Corina
Behavioral and Brain Sciences
Published online: 4 February 2010

Article

A worthy enterprise injured by overinterpretation and misrepresentation

Marc D. Hauser and Jon Sakata

Behavioral and Brain Sciences

Published online: 4 February 2010

Article

Double dissociation, modularity, and distributed organization

John A. Bullinaria and Nick Chater

Behavioral and Brain Sciences

Published online: 4 February 2010

Article

Evolutionary principles and the emergence of syntax

P. Thomas Schoenemann and William S.-Y. Wang

Behavioral and Brain Sciences

Published online: 4 February 2010

