Concepts and Semantic Memory

BARBARA C. MALT

Abstract

Humans accumulate vast amounts of knowledge over the life span. Much work aimed at understanding this knowledge store has been called either *concepts* or *semantic memory* research. This essay reviews early research on the nature of concrete concepts (concepts of concrete objects) and their organization in memory. It then raises considerations of abstract and relational concepts and of how action affects representation and vice versa. Additional advances discussed come from statistically based views of semantics, connectionist modeling, and neuroscientific evidence, all showing how distributed sources of information can be integrated to create semantic or conceptual content. Cross-cultural and cross-linguistic evidence indicate, though, that models based on evidence from any one cultural or language group may not apply well to others. The essay concludes by arguing that key issues for future research include broadening the kinds of knowledge structures that are studied and clarifying how language and nonlinguistic representations are related.

INTRODUCTION

The flexibility in how humans respond to their environment is unmatched by any other species. This flexibility is due, in part, to the vast amount of knowledge that each person accumulates over the life span. Much work aimed at understanding this mental database has been called either "concepts" or "semantic memory" research.

The dual terminology raises the questions of what each term means and what their relation is. Semantic memory is often said to be general world knowledge, contrasted with autobiographical memory (memory for specific events). Concepts are generally taken to be stable units of knowledge in long-term memory that pick out meaningful sets of entities in the world and that provide the elements out of which more complex thoughts are constructed. Practically speaking, the concepts of interest are typically the knowledge associated with words such as *apple*, *bird*, and *chair*. Given these characterizations, concepts would be one kind of knowledge within a larger system. That would leave much else to investigate about the nature and contents of general world knowledge.

Emerging Trends in the Social and Behavioral Sciences. Edited by Robert Scott and Stephen Kosslyn.
 ISBN 978-1-118-90077-2.

In reality, though, researchers who do "semantic memory" research and those who do "concepts" research have traditionally addressed similar issues. Early on, those interested in semantic memory pursued a line of work inspired by Collins and Quillian (1969), investigating the organization in memory and processing of knowledge associated with common nouns such as those just mentioned. Meanwhile, "concepts" research emerged from a line of work focusing on human acquisition of artificial (experimenter-generated) categories. With the advent of Eleanor Rosch's work (e.g., Rosch & Mervis, 1975; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976) on natural categories (those named by common nouns) and Smith and Medin's (1981) book *Concepts and categories*, the modern era of research on concepts that people acquire from the real world was launched.

The early convergence of the "semantic memory" and "concepts" endeavors is illustrated in work examining the relation in memory of representations such as APPLE to FRUIT and the processes involved in making judgments about them (such as answering *Is an apple a fruit?*) (e.g., Smith, Shoben, & Rips, 1974). This research appears reliably in discussions of both concepts and semantic memory. Indeed, to some extent, early "semantic memory" researchers simply relabeled themselves as "concepts" researchers as work by Rosch *et al*. came to the forefront (Rips, Smith, & Medin, 2012).

To the extent that a distinction persisted in the early decades, it might be said that researchers associated with concepts were more interested in the structure and content of individual concepts, and those associated with semantic memory were more interested in how concepts were organized in memory and how retrieval processes operated on them. However, the boundary between the two research areas is fuzzy and not consistently drawn. The following discussion does not attempt to label individual bodies of research as one or the other. An important question we will return to, though, is what remains to be understood about general world knowledge beyond what currently is studied under either rubric.

FOUNDATIONAL RESEARCH

THE STRUCTURE AND CONTENT OF CONCEPTS

Rosch's work in the 1970s was inspired in part by observations by the philosopher Wittgenstein, who had provided an important analysis of the meaning of common nouns such as *game*. Wittgenstein pointed out the impossibility of finding a set of features that are necessary and sufficient for some activity to be called a *game*. For instance, some games involve balls but others do not, some have a winner and loser but some do not, and some are not even fun although most may be. Wittgenstein argued that the things called *game* have a family resemblance to each other: They overlap with one another in varied ways rather than sharing a single set of features. Rosch and Mervis (1975) proposed that the family resemblance analysis applied to many common nouns, and they provided evidence in the form of the feature distributions people produced to exemplars of many common nouns.

There are several important corollaries of Rosch and Mervis' analysis. One is that the things called by a given name vary in their typicality with respect to the name. The more an entity shares features with other things called by that name, the more typical it is. Typicality is an important predictor of behavior in many tasks, ranging from speed to verify an instance as having a name (e.g., answering *Is a robin a bird?*) to how early children learn that relationship. Second, the most typical examples of categories serve as a prototype associated with the name, and, as such, might provide a summary mental representation of the category. Third, properties in the world occur in clusters. For instance, creatures with feathers tend to have wings and beaks, and creatures with fur tend not to. These property clusters might provide natural "break points" for perception. If so, natural categories are natural not only in the sense of contrasting with artificial, experimenter-generated ones, but in the sense that they are the result of a natural segmentation of the world easily perceived by human observers.

Studies using artificial categories supported the idea that prototypes might constitute the mental representation of sets of exemplars. However, models assuming that people accumulate traces of individual exemplars of a category as their representation can account for the same results. These exemplar models have received much less vetting for their ability to account for performance on tasks with real-world concepts, but some work suggests that they are useful (e.g., Storms, 2004). Knowledge of instances does not preclude also having a summary representation in the form of a prototype, however, and other work has supported the possibility of people maintaining both (Smith & Minda, 1998).

Later work elaborated on the contents of the mental representations. Knowledge of BIRD cannot be only a set of features. The relation between having wings and flying (causal) is understood as different from the relation between having wings and eating seed (mere co-occurrence). Feature knowledge is embedded in a rich set of intuitive theories about how the world works (see Murphy, 2002, ch. 6). Theories and beliefs about causation may be particularly important. For instance, features that are causes of other features are seen as particularly central to category membership (Ahn & Kim, 2001) Another overarching folk theory is that many categories have an unseen, underlying essence shared by category members (e.g., Medin & Ortony, 1989). Even if it is impossible in reality to find such essences, people may still believe they exist and appeal to them in their judgments (Keil, 1989).

Given these enriched ideas about the content of concepts, the possibility is also opened up that the contents will differ across domains (such as naturally occurring things—water, gold, cats, and dogs—vs human-made ones—chairs, tables, and pens and pencils). People tend to believe that naturally occurring things have essences but artifacts do not (e.g., Malt, 1990). Furthermore, knowledge of living things and artifacts is observed to be differentially affected by brain damage. Patients can have degraded ability to understand one without harm to the other (see Yee, Chrysikou, & Thompson-Schill, 2013). This suggests some domain-specificity in their representation.

The early research was dominated by investigations of concepts having a taxonomic or "kind" relation to one another (e.g., ROBIN is a kind of BIRD), but an early departure from this tradition was made by Barsalou (1991). He pointed out that people also use groupings that are created on the spot to serve particular purposes. For instance, when faced with a fire in the house, a person might construct a grouping of the things that should be rescued first (including, say, pets, photos, and jewelry). What unites the things in this category is their importance in the person's life, not overlapping properties such as fur or feathers.

Organization of Concepts in Memory and Retrieval from Memory

Several insights emerged from this era on how concepts are related to one another and retrieved from memory. Rosch *et al*. (1976) noted that common objects can be labeled at multiple levels of abstraction: *rocking chair*, *chair*, or *furniture*, for instance. They observed that the middle level is the level at which objects are most commonly named: *chair* rather than *rocking chair* or *furniture*. This "basic" level is also the level first learned by children, and the level at which objects are most quickly identified, suggesting that it is the most salient and useful. Rosch *et al*. proposed that it is the level at which things within a category are substantially similar while still being distinct from things in contrasting categories.

Collins and Quillian (1969) suggested that concept hierarchies are embedded in a semantic network linking CHAIR not only to ROCKING CHAIR and FURNITURE but also to BENCH and TABLE, and each of these to properties such as WOOD and HAS LEGS. Collins and Loftus (1975) further suggested that once one concept has been activated, activation spreads along the links within the network, activating other nearby concepts. Given the network structure and spreading activation, predictions can be made about how easy it should be to answer questions such as *Is a robin a bird?* versus *Is a robin an animal?*, as well as about whether activating a concept such as DOCTOR should speed responses to others such as NURSE versus BUTTER. The work by Smith *et al*. (1974) mentioned earlier suggested the need for some refinements (such as allowing that ROBIN might be closer to BIRD than DUCK based on typicality). However, the general notion that concepts are interconnected in a massive network of associations, and that retrieving some information can activate related material, has remained in place.

CUTTING-EDGE RESEARCH

Linking Content to Organization and Process

Recent threads of research have broadened the range of concepts studied and promoted new ways of thinking about the content of individual concepts. In doing so, ideas about the representation of individual concepts have become more integrated with ones about processing and the relations among concepts.

Attention to abstract concepts (e.g., FAITH, BEAUTY) has led to asking whether representations of abstract and concrete words differ only in content, or whether a crucial difference lies in their connections to other concepts within the semantic network. For instance, abstract concepts may have more emotion-related features and fewer sensorimotor ones (e.g., Kousta, Vigliocco, Vinson, Andrews, & Del Campo, 2011). However, abstract ones may also tend to have connections dominated by associations (e.g., FAITH is connected to GOD and FIDELITY), while concrete concepts have ones dominated by categorical relations (e.g., DOG is connected to CAT and MAMMAL) (Crutch & Warrington, 2005). Separately, the notion of relational knowledge has also become more prominent. In some cases, important relations are captured by individual words. Gentner and Kurtz (2005), for instance, describe the meanings of *gift* and *predator* as centering on relations rather than properties intrinsic to the entity. In other cases, what is of interest is thematic links among different entities within the semantic network, such as the relations between a cow and milk or a boat and an anchor (e.g., Estes, Golonka, & Jones, 2011), again blurring the line between representation and organization.

Work on how concept use affects concept contents, and vice versa, more explicitly links processing to representation. Concepts are shaped by input conditions. The focus of learning (whether to learn to distinguish categories per se or to learn about the properties that entities have) influences the knowledge that is acquired about instances of a category. Other types of interactions with instances do, too, as when people put knowledge to use. For instance, making treatment decisions given symptoms (Markman & Ross, 2003), affects disease category representations. The other side of the coin is how knowledge is translated into action. Representation affects how humans interact with each other. For instance, physician beliefs about a child's home, school, and peers contexts affects diagnosis of mental disorders (De Los Reyes & Marsh, 2011).

Even more closely integrating action and representation is an approach to the nature of concepts known as the *embodiment perspective*. Traditionally, the conceptual system was said to contain amodal knowledge, meaning that experiences taken in through the senses are converted to a more abstract representational format. Counter to such assumptions, an explosion of recent research has demonstrated that sensorimotor variables affect performance in diverse tasks. For instance, verifying a property in the auditory modality (e.g., BLENDER-loud) is slower after verifying a taste property (e.g., CRANBERRIES-tart) than after verifying another auditory property (e.g., LEAVES-rustling). Activating stored knowledge of a word is said to entail mentally simulating the actual experience of encountering its referent in the world. In this view, the representations themselves are rooted in systems for perception, action, and emotion (see Barsalou, Simmons, Barbey, & Wilson, 2003).

COMPUTATIONAL AND NEUROSCIENTIFIC ADVANCES: DISTRIBUTIONAL STATISTICS AND DISTRIBUTED REPRESENTATIONS

New methodologies have brought further insights into both representation and processing. In doing so, they have helped show how the boundaries between these two components of cognition are blurred.

Computation-intensive distributional models of semantics assume that words appearing in similar linguistic contexts have similar meanings, and that meaning can be deduced from the distribution of uses. From massive inputs of discourse in the form of electronic corpora, word meanings are constructed using information about word co-occurrences in the data. The models differ substantially in detail, but all have the advantage of demonstrating how semantic representations might be acquired from environmental input. Although they do not necessarily account well for basic patterns of word choice (Murphy, 2002, ch. 11), recent models integrating feature-based representations with corpus-derived co-occurrence data may help address such issues (see McRae & Jones, 2013.)

A different computational approach lies in connectionist modeling. While the Collins and Quillian-type semantic network represented each concept as a unitary node in memory, connectionism opened the possibility of re-envisioning them in terms of patterns of activations across nodes that individually have no conceptual content (e.g., Rogers & McClelland, 2004). The same nodes participate in the representation of multiple concepts via different patterns of activation across them. The patterns of activation capture the similarities among concepts, with concepts having more shared features producing more similar patterns of activation. Connectionist models can model the acquisition of concept knowledge through gradual adaptation of the connection weights between nodes, sharing with distributional models the advantage of showing how representations may emerge from input. They can also simulate the selective loss of knowledge through distortions of weights, and they demonstrate how behavioral results (for instance, speed to verify properties or class-inclusion relations) can be modeled even if the association-based network as a literal map of how knowledge is laid out in the brain is false.

The other major methodological advance has been in the area of cognitive neuroscience. The most important technique has been functional neuroimaging looking at what brain regions are active in processing words and pictures of objects. Results support the embodiment perspective on conceptual representation. Activating object concepts elicits patterns of neural activity in regions close to, if not identical to, those involved in perceiving and interacting with the actual objects. The same is true for perceiving color and thinking about the colors of objects, and for carrying out actions and thinking about the meaning of action words. For instance, thinking about pianos and typewriters create similar patterns of activation in motor regions of the brain, and reading a word strongly associated with a sound, such as *telephone*, activates regions involved in auditory perception and processing (see Martin, 2007; Yee *et al*., 2013). In short, stored knowledge about objects entails a great deal of sensorimotor knowledge, and activating the knowledge engages relevant sensorimotor regions of the brain.

Such evidence also highlights new possibilities for thinking about the overall organization of conceptual knowledge in the brain. If object knowledge is represented in terms of sensorimotor and other attributes distributed across different brain areas, it is less localized. A representation about telephones would involve sound, but it would also involve purpose, shape, and several types of motor activity (holding, dialing, and speaking), distributed across different regions. Theories differ in specifics, but all are in agreement that conceptual representations are distributed in some manner. A central hub or convergence zone may integrate the information across modalities to create the experience of a unified thought about an entity (see Yee *et al*., 2013, for review). By moving away from notions of unitary concept nodes and localized representation, this perspective is broadly compatible with connectionist models of semantic knowledge.

Although studies of brain damage had shown that people can have deficits for some types of concepts but not others, a difficulty for the idea of domain-specific neural representation has been that the deficits do not always respect the living thing versus artifact domain boundary. An appealing aspect of the newer approach is that it can explain differential degradation of knowledge in terms of the features involved. Although artifact representations may tend to involve more function-related features and living things more sensory attributes, there can be variation across individual entities. This variation may account for variable loss within a domain (see Yee *et al*., 2013).

ANGLOS ARE NOT PEOPLE

Yes, English-speaking people of European descent *are* people in an important sense. But when researchers talk about how "people" represent or use knowledge, English speakers of European descent are not necessarily a good gauge of "people" in general. Cognitive psychology spent its first decades focused on this population. In many areas of psychology there is now interest in the generalizability of findings and theories to other cultures (e.g., Henrich, Heine, & Norenzayan, 2010). Under the umbrella of concepts and semantic memory, however, work on other cultural groups has been limited. Pioneering research comes from Douglas Medin's group (e.g., Atran & Medin, 2008), which has examined cultural differences in intuitive theories about nature and the human place within nature. This work demonstrates that differences can be pronounced and impact decisions and behaviors toward the environment.

Other researchers have been motivated by observations about language. It has become apparent that languages have different ways of dividing up domains. For instance, English, Chinese, and Spanish group common household containers differently by name. Such differences have been documented for domains including color, number, plants and animals, drinking vessels and household containers, body parts, spatial relations, locomotion, acts of cutting and breaking, acts of carrying and holding (see Malt & Majid, 2013, for review). These observations mean that when words of one language (e.g., *robin*, *chair*) are used to identify concepts, the concepts may be language-specific. Some researchers have begun to look for shared components of word meaning underlying cross-linguistic variation (see Malt & Majid, 2013) as a way to identify aspects of understanding of the world that are language-general. Work on animal cognition and concepts (e.g., Phillips & Santos, 2007) also helps identify aspects of conceptual thought that occur across species and so are not language-dependent.

KEY ISSUES FOR FUTURE RESEARCH

The Rest of Semantic Memory

Semantic memory as "general world knowledge" in principle encompasses much more than units of knowledge labeled by single words. Existing research on concepts and semantic memory by no means provides a complete picture of general world knowledge.

Some decades ago, researchers identified other kinds of knowledge structures that are important in guiding thought and behavior. For instance, work on "scripts" (e.g., Schank & Abelson, 1977) illustrated how people use knowledge of standard event sequences (e.g., having a restaurant meal) to interpret events and select behaviors. Other larger scale knowledge structures such as culture-specific formulas for telling a story (e.g., Mandler & Johnson, 1977) and the "mental models" that people have of complex phenomena such as the solar system and electricity (Gentner & Stevens, 1983) also are critical to how people understand the world and act on it.

More recent related work does exist, such as that by Medin and colleagues on how different cultural groups understand the natural world. Also in a related vein is work on intuitive theories, explanatory schemes, and causal understanding (e.g., Keil, 2006). An intriguing observation in some of this work is how fragmentary the knowledge of some domains can be despite a person's sense that they understand the domain, and how inconsistent people can be in the judgments they make and conclusions they draw, depending on what elements of knowledge are retrieved in a given context (Shtulman & Valcarcel, 2012). Understanding these forms of knowledge and how they are used is essential to addressing societal problems such as threats to the environment and achieving success in education.

None of these threads of research is well integrated with work labeled "semantic memory." The challenge will be to work out how knowledge at different scales and levels of complexity are related to each other and interact in determining thought and behavior. This integration is necessary for an understanding of general world knowledge.

The Language–Concepts Interface

A persistent haze has lingered over research in concepts and semantic memory about what exactly is the topic of investigation. Is it general-purpose mental representations of the world, or is it words and their meanings as part of the linguistic system? Some researchers talk about concepts, some about word meanings, and some use the terms interchangeably. The confusion over concepts versus word meanings also applies to the study of "conceptual combination," which is said to be about how simple concepts are combined to create more complex ones (see Murphy, 2002, ch. 12), but which in practice is about how noun phrases (such as *chocolate bee* or *ocean bird*) are interpreted. Meanwhile, "polysemy" or the multiple senses associated with a single word is routinely treated by cognitive psychologists as a feature of language, although the units involved are presumably exactly the same as those called *concepts* in other contexts.

A commitment to the idea that lexicalized concepts are the ones used in general nonlinguistic cognitive tasks is in line with the Whorfian hypothesis that language strongly shapes an individual's understanding of the world. However, much recent research on the Whorfian hypothesis favors weaker interpretations of linguistic effects on thought, such as that they are momentary, online effects (e.g., Athanasopoulos & Bylund, 2013). Figuring out how nonlinguistic and linguistic knowledge interface and interact will be an important task for the future. Answers may help with gaining traction on "conceptual combination," which remains without a satisfactory account. Similarly, clarifying when deficits due to brain damage reflect disruption to conceptual knowledge, language processing, or the interface between the two may help with models to account for such deficits. Traditionally separate literatures on language production and on bilingual word learning and lexical access also stand to benefit from clarifying the language–thought interface.

One possible resolution is that no fixed concepts or word meanings exist. If conceptual knowledge is stored in a distributed manner across the brain and, metaphorically, in the mind, stimuli or tasks can selectively recruit portions of this knowledge. Some stimuli and tasks may activate linguistic knowledge and some may not. Online construction of concepts has been proposed in the past (e.g., Barsalou, 1987). Online construction of word meaning also has been proposed before and helps solve the problems of how senses vary with context and how a single word can have indefinitely many senses (e.g., Clark, 1983). Most recently, online construction of word meaning has been suggested in the context of distributional models of semantics (Kintsch & Mangalath, 2011). Proposals of this sort have been the minority view to date. In light of the recent advances in modeling and neuroscience, they may be poised to become more dominant.

ACKNOWLEDGMENTS

Preparation of this essay was supported in part by National Science Foundation Grant Number 1057885 to Barbara Malt and Ping Li. I thank Gordon Bower and Doug Medin for discussion and Jessecae Marsh and Gregory Murphy for comments on a previous draft.

REFERENCES

Ahn, W.-k., & Kim, N. S. (2001). The causal status effect in categorization: An overview. In D. L. Medin (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 40, pp. 23–65). San Diego, CA: Academic Press.

Athanasopoulos, P., & Bylund, E. (2013). Does grammatical aspect affect motion event cognition? A cross-linguistic comparison of English and Swedish speakers. *Cognitive Science*, *37*, 286–309.

Atran, S., & Medin, D. L. (2008). *The native mind and the cultural construction of nature*. Boston, MA: MIT Press.

Barsalou, L. W. (1987). The instability of graded structure: Implications for the nature of concepts. In U. Neisser (Ed.), *Concepts and conceptual development: Ecological and intellectual factors in categorization* (pp. 101–140). Cambridge, England: Cambridge University Press.

Barsalou, L. W. (1991). Deriving categories to achieve goals. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 27, pp. 1–64). San Diego, CA: Academic Press.

Barsalou, L. W., Simmons, W. K., Barbey, A. K., & Wilson, C. D. (2003). Grounding conceptual knowledge in modality-specific systems. *Trends in Cognitive Sciences*, *7*, 84–91.

Clark, H. H. (1983). Making sense of nonce sense. In G. B. Flores d'Arcais & R. J. Jarvella (Eds.), *The process of language understanding* (pp. 297–331). London, England: Wiley.

Collins, A. M., & Loftus, E. F. (1975). A spreading activation theory of semantic processing. *Psychological Review*, *82*, 407–428.

Collins, A. M., & Quillian, M. R. (1969). Retrieval time from semantic memory. *Journal of Verbal Learning and Verbal Behavior*, *8*, 241–248.

Crutch, S., & Warrington, E. K. (2005). Abstract and concrete concepts have structurally different representational frameworks. *Brain*, *128*, 615–627.

De Los Reyes, A., & Marsh, J. K. (2011). Patients' contexts and their effects on clinicians' impressions of conduct disorder symptoms. *Journal of Clinical Child and Adolescent Psychology*, *40*, 479–485.

Estes, Z., Golonka, S., & Jones, L. L. (2011). Thematic thinking: The apprehension and consequences of thematic relations. In B. Ross (Ed.), *Psychology of learning and motivation* (Vol. 54, pp. 249–294). Burlington, Canada: Academic Press.

Gentner, D., & Kurtz, K. J. (2005). Relational categories. In W.-k. Ahn, R. L. Goldstone, B. C. Love, A. B. Markman & P. Wolff (Eds.), *Categorization inside and outside the laboratory: Essays in honor of Douglas L. Medin* (pp. 151–175). Washington, DC: American Psychological Association.

Gentner, D., & Stevens, A. L. (Eds.) (1983). *Mental models*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*, 1–23.

Keil, F. C. (1989). *Concepts, kinds, and cognitive development*. Cambridge, MA: MIT Press.

Keil, F. C. (2006). Explanation and understanding. *Annual Review of Psychology*, *57*, 227–254.

Kintsch, W., & Mangalath, P. (2011). The construction of meaning. *Topics in Cognitive Science*, *3*, 346–370.

Kousta, S.-T., Vigliocco, G., Vinson, D. P., Andrews, M., & Del Campo, E. (2011). The representation of abstract words: Why emotion matters. *Journal of Experimental Psychology: General*, *140*, 14–34.

Malt, B. C. (1990). Features and beliefs in the mental representation of categories. *Journal of Memory and Language*, *29*, 289–315.

Malt, B. C., & Majid, A. (2013). How thought is mapped into words. *WIREs Cognitive Science*, *4*, 583–597.

Mandler, J. M., & Johnson, N. S. (1977). Remembrance of things parsed: Story structure and recall. *Cognitive Psychology*, *9*, 111–151.

Markman, A. B., & Ross, B. H. (2003). Category use and category learning. *Psychological Bulletin*, *129*, 592–613.

Martin, A. (2007). The representation of object concepts in the brain. *Annual Review of Psychology*, *58*, 25–45.

McRae, K., & Jones, M. N. (2013). Semantic memory. In D. Reisberg (Ed.), *The Oxford handbook of cognitive psychology* (pp. 206–219). Oxford, England: Oxford University Press.

Medin, D. L., & Ortony, A. (1989). Psychological essentialism. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 179–195). Cambridge, England: Cambridge University Press.

Murphy, G. L. (2002). *The big book of concepts*. Cambridge, MA: The MIT Press.

Phillips, W., & Santos, L. R. (2007). Evidence for kind representations in the absence of language: Experiments with rhesus monkeys (Macaca mulatta). *Cognition*, *102*, 455–463.

Rips, L. J., Smith, E. E., & Medin, D. L. (2012). Concepts and categories: Memory, meaning, and metaphysics. In K. J. Holyoak & R. G. Morrison (Eds.), *The Oxford handbook of thinking and reasoning* (pp. 177–209). Oxford, England: Oxford University Press.

Rogers, T. T., & McClelland, J. L. (2004). *Semantic cognition: A parallel distributed processing approach*. Cambridge, MA: MIT Press.

Rosch, E., & Mervis, C. B. (1975). Family resemblances: Studies in internal structure of categories. *Cognitive Psychology*, *7*, 573–605.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology*, *8*, 382–439.

Schank, R. C., & Abelson, R. P. (1977). *Scripts, plans, goals, and understanding: An inquiry into human knowledge structures*. Hillsdale, NJ: Erlbaum.

Shtulman, A., & Valcarcel, J. (2012). Scientific knowledge suppresses but does not supplant earlier intuitions. *Cognition*, *124*, 209–215.

Smith, E. E., & Medin, D. L. (1981). *Categories and concepts*. Cambridge, MA: Harvard University Press.

Smith, E. E., Shoben, E. J., & Rips, L. J. (1974). Structure and process in semantic memory: A featural model for semantic decisions. *Psychological Review*, *81*, 214–241.

Smith, J. D., & Minda, J. P. (1998). Prototypes in the mist: The early epochs of category learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*, 1411–1436.

Storms, G. (2004). Exemplar models in the study of natural language concepts. *Psychology of Learning and Motivation*, *45*, 1–39.

Yee, E., Chrysikou, E. G., & Thompson-Schill, S. L. (2013). Semantic memory. In K. Ochsner & S. Kosslyn (Eds.), *The Oxford handbook of cognitive neuroscience, Vol. 1: Core topics* (pp. 353–374). Oxford, England: Oxford University Press.

FURTHER READING

Atran, S., & Medin, D. L. (2008). *The native mind and the cultural construction of nature*. Boston, MA: MIT Press.

Barsalou, L. B. (2008). Grounded cognition. *Annual Review of Psychology*, *59*, 617–645.

Keil, F. C. (2006). Explanation and understanding. *Annual Review of Psychology*, *57*, 227–254.

Malt, B. C., & Majid, A. (2013). How thought is mapped into words. *WIREs Cognitive Science*, *4*, 583–597.

McRae, K., & Jones, M. N. (2013). Semantic memory. In D. Reisberg (Ed.), *The Oxford handbook of cognitive psychology* (pp. 206–219). Oxford, England: Oxford University Press.

Murphy, G. L. (2002). *The big book of concepts*. Cambridge, MA: The MIT Press.

Rogers, T. T., & McClelland, J. L. (2004). *Semantic cognition: A parallel distributed processing approach*. Cambridge, MA: MIT Press.

Yee, E., Chrysikou, E. G., & Thompson-Schill, S. L. (2013). Semantic memory. In K. Ochsner & S. Kosslyn (Eds.), *The Oxford handbook of cognitive neuroscience, Vol. 1: Core topics* (pp. 353–374). Oxford, England: Oxford University Press.

BARBARA C. MALT SHORT BIOGRAPHY

Barbara C. Malt is a Professor of Psychology at Lehigh University. Her research focuses on thought, language, and the relation between the two. She is especially interested in how objects and actions are mentally represented, how people (including monolinguals and bilinguals, both children and adults) talk about these objects and actions using the tools available in their language(s), and what influence, if any, the different ways of talking have on nonlinguistic representations. She is an associate editor for the *Journal of Experimental Psychology: Learning, Memory, and Cognition*. More information can be found at http://www.lehigh.edu/~bcm0/bcm0/index.html

RELATED ESSAYS

Language, Perspective, and Memory *(Psychology)*, Rachel A. Ryskin *et al.*

Misinformation and How to Correct It *(Psychology)*, John Cook *et al*.

Language and Thought *(Psychology)*, Susan Goldin-Meadow

Social Aspects of Memory *(Psychology)*, William Hirst and Charles B. Stone

Implicit Memory *(Psychology)*, Dawn M. McBride
Memory Gaps and Memory Errors *(Psychology)*, Jeffrey S. Neuschatz *et al.*
Theory of Mind *(Psychology)*, Henry Wellman