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Whorfian Hypothesis
Daniel Casasanto

Introduction

The Sapir-Whorf hypothesis (a.k.a. the Whorfian hypothesis) concerns the relationship between language and thought. Neither the anthropological linguist Edward Sapir (b. 1884–d. 1939) nor his student Benjamin Whorf (b. 1897–d. 1941) ever formally stated any single hypothesis about the influence of language on nonlinguistic cognition and perception. On the basis of their writings, however, two proposals emerged, generating decades of controversy among anthropologists, linguists, philosophers, and psychologists. According to the more radical proposal, *linguistic determinism*, the languages that people speak rigidly determine the way they perceive and understand the world. On the more moderate proposal, *linguistic relativity*, habits of using language influence habits of thinking. As a result, people who speak different languages think differently in predictable ways. During the latter half of the 20th century, the Sapir-Whorf hypothesis was widely regarded as false. Around the turn of the 21st century, however, experimental evidence reopened debate about the extent to which language shapes nonlinguistic cognition and perception. Scientific tests of linguistic determinism and linguistic relativity help to clarify what is universal in the human mind and what depends on the particulars of people's physical and social experience.

General Overviews and Foundational Texts

Writing on the relationship between language and thought predates Sapir and Whorf, and extends beyond the academy. The 19th-century German philosopher Wilhelm von Humboldt argued that language constrains people's worldview, foreshadowing the idea of linguistic determinism later articulated in Sapir 1929 and Whorf 1956 (Humboldt 1988). The intuition that language radically determines thought has been explored in works of fiction such as Orwell's dystopian fantasy *1984* (Orwell 1949). Although there is little empirical support for radical linguistic determinism, more moderate forms of linguistic relativity continue to generate influential research, reviewed from an anthropologist's perspective in Lucy 1997, from a psychologist's perspective in Hunt and Agnoli 1991, and discussed from multidisciplinary perspectives in Gumperz and Levinson 1996 and Gentner and Goldin-Meadow 2003.

Gentner, Dedre, and Susan Goldin-Meadow, eds. 2003. *Language in mind: Advances in the study of language and thought*. Cambridge, MA: MIT Press.

Edited volume containing position papers for and against linguistic relativity. Includes reviews of some of the experimental studies that revived widespread interest in the Sapir-Whorf hypothesis at the beginning of the 21st century.

Gumperz, John J., and Stephen C. Levinson, eds. 1996. *Rethinking linguistic relativity*. Studies in the Social and Cultural Foundations of Language 17. Cambridge, UK: Cambridge Univ. Press.

Edited volume containing position papers for and against linguistic relativity. A cross-section of Whorfian research in anthropology, psychology, and linguistics at the end of the 20th century.

Humboldt, Wilhelm von. 1988. *On language: The diversity of human language-structure and its influence on the mental development of mankind*. Translated by Peter Heath. Cambridge, UK: Cambridge Univ. Press.

Humboldt argues that language determines one's world view.

Hunt, Earl, and Franca Agnoli. 1991. The Whorfian hypothesis: A cognitive psychology perspective. *Psychological Review* 98.3: 377–389.

A critical review of 20th-century Whorfian research, in which the authors sketch proposals for several studies that were brought to fruition

by other researchers over the ensuing two decades.

Lucy, John A. 1997. Linguistic relativity. *Annual Review of Anthropology* **26:291–312.**

A review focusing on the various ways in which the Whorfian question was approached empirically during the 20th century.

Orwell, George. 1949. *1984: A novel***. New York: Harcourt, Brace.**

Fictitious account of a totalitarian state in which language is used to control thought.

Sapir, E. 1929. The status of linguistics as a science. *Language* **5:207–214.**

Sapir states the view that language shapes one's worldview, subsequently called linguistic determinism.

Whorf, Benjamin Lee. 1956. *Language, thought, and reality: Selected writings of Benjamin Lee Whorf***. Edited by John B. Carroll. Cambridge, MA: MIT Press.**

The definitive collection of Whorf's writings, some posthumously published.

Journals

For further reading, the following journals have a record of publishing important papers on the relationship between language and thought, reporting research in anthropology (e.g., American Anthropologist), psychology (e.g., Cognitive Psychology; Journal of Experimental Psychology: General; Psychological Science), and interdisciplinary cognitive science (e.g., Cognition; Cognitive Science; Language and Cognition; Trends in Cognitive Sciences).

American Anthropologist.

The flagship journal of the American Anthropological Association. Peer reviewed. An outlet for archaeological, biological, ethnological, and linguistic research.

Cognition.

An international journal of cognitive science. Peer reviewed. Published by Elsevier. Publishes theoretical and experimental papers on all aspects of cognition. Several influential debates relevant to the Sapir-Whorf hypothesis have appeared here, in the form of a series of independently submitted papers.

Cognitive Psychology.

Published by Elsevier. Peer reviewed. Publishes empirical, theoretical, and tutorial papers; methodological articles; and critical reviews. Focuses on empirical articles that provide major theoretical advances in the study of cognition.

Cognitive Science

Journal of the Cognitive Science Society. Peer reviewed. Published by Wiley-Blackwell. Promotes scientific interchange among researchers in disciplines comprising the field of cognitive science, including artificial intelligence, linguistics, anthropology, psychology, neuroscience, philosophy, and education.

Journal of Experimental Psychology: General.

Published by the American Psychological Association. Peer reviewed. Publishes major experimental papers of broad interest.

Language and Cognition.

The journal of the UK Cognitive Linguistics Association. Peer reviewed. Published by Mouton de Gruyter. An outlet of theoretical and empirical papers exploring the interface between language and cognition.

Psychological Science.

Flagship journal of the Association for Psychological Science. Peer reviewed. Publishes brief experimental reports of broad interest in psychology and neuroscience.

Trends in Cognitive Sciences.

Published by Cell Press. Peer reviewed. Publishes brief reviews of current research and opinion, about all aspects of cognition.

Anti-Whorfian Literature

During the latter half of the 20th century, some of the most memorable writing about the Whorfian hypothesis was by its opponents. Leading figures in linguistics (Chomsky 1973), philosophy (Fodor 1985), and psychology (Pinker 1994) appear to have been vying to see who could denounce the notion of linguistic relativity the most emphatically, or the most humorously (Pullum 1991). Even as studies accumulated that caused some scholars to reexamine the Whorfian question in the 21st century, others remained convinced that the Sapir-Whorf hypothesis was flawed in principle (Bloom and Keil 2001), or that the empirical support was weak (Gleitman and Papafragou 2005, Munnich and Landau 2003) or uninteresting (Pinker 2007).

Bloom, Paul, and Frank C. Keil. 2001. Thinking through language. *Mind and Language* 16.4: 351–367.

Critique of the Sapir-Whorf hypothesis and the data supporting it.

Chomsky, Noam. 1973. Introduction. In *Language and cognition*. By Adam Schaff, iii–x. New York: McGraw-Hill.

An "extremely skeptical" (p. x) assessment of Adam Schaff's pro-Whorfian stance by an eminent linguist.

Fodor, Jerry A. 1985. Précis of *The modularity of mind*. *Behavioral and Brain Sciences* 8:1–42.

Statement about the relations among language, cognition, and perception by an eminent philosopher of mind, who states that he "hate[s]" the notion of relativity (linguistic, cultural, etc. [p. 5]).

Gleitman, Lila, and Anna Papafragou. 2005. Language and thought. In *The Cambridge handbook of thinking and reasoning*. Edited by Keith J. Holyoak and Robert G. Morrison, 633–662. New York: Cambridge Univ. Press.

Review and critique of Whorfian research by one of its most outspoken opponents (Gleitman).

Munnich, Edward, and Barbara Landau. 2003. The effect of spatial language on spatial representations: Setting some boundaries. In *Language in mind: Advances in the study of language and thought*. Edited by Dedre Gentner and Susan Goldin-Meadow, 113–155. Cambridge, MA: MIT Press.

A review and skeptical evaluation of Whorfian research, including some research from the early 21st century.

Pinker, Steven. 1994. *The language instinct: How the mind creates language*. New York: William Morrow.

An eminent psychologist argues that the Whorfian hypothesis is "wrong, all wrong" (p. 57).

Pinker, Steven. 2007. *The stuff of thought: Language as a window into human nature*. New York: Viking.

A broad and engaging book on relationships between language and thought, which includes a skeptical appraisal of Whorfian research in the early 21st century.

Pullum, Geoffrey K. 1991. *The great Eskimo vocabulary hoax and other irreverent essays on the study of language*. Chicago: Univ. of Chicago Press.

A humorous and insightful critique of linguistic data and argumentation for the Whorfian hypothesis.

Pro-Whorfian Literature

Nearly all pro-Whorfian writing begins with an acknowledgment of the controversy surrounding the Sapir-Whorf hypothesis, and of the limitations of previous Whorfian research. In the following books and articles, the authors provide reasons why decades of controversy should not cause readers to reject the notion of linguistic relativity, marshaling theoretical arguments, empirical data, and experimental methods that provide new answers to long-debated questions. Carroll's introduction to *Language, Thought, and Reality* (Carroll 1956) provides an overview of Whorf's life and work. Lee 1996 provides a thorough exegesis and reanalysis of writing by Whorf and his critics. Levinson 2003 seeks to sort out some of the sources of real or perceived disagreement among pro- and anti-Whorfian researchers. Schaff 1973 applies Whorfian arguments to philosophy and political theory. Lenneberg 1953, Slobin 1996, and Casasanto 2008 each introduce new theoretical perspectives and innovative methods for testing the Whorfian hypothesis. Boroditsky 2003 briefly reviews some of the experimental studies conducted by psychologists and linguistic anthropologists around the turn of the 21st century.

Boroditsky, Lera. 2003. Linguistic relativity. In *Encyclopedia of cognitive science*. Vol. 2. Edited by Lynn Nadel, 917–921. London: Nature Publishing.

A brief review of Whorfian research by a leading scholar, focusing on the first wave of experimental studies that marked a resurgence of interest in the Sapir-Whorf hypothesis at the beginning of the 21st century.

Carroll, John B. 1956. Introduction. In *Language, thought, and reality: Selected writings of Benjamin Lee Whorf*. By Benjamin Lee Whorf, 1–34. Cambridge, MA: MIT Press.

An overview of Whorf's life and work.

Casasanto, Daniel. 2008. Who's afraid of the big bad Whorf? Crosslinguistic differences in temporal language and thought. *Language Learning* 58.S1: 63–79.

A refutation of anti-Whorfian arguments in Pinker 1994 (cited under Anti-Whorfian Literature) and other works, and a demonstration of methods that make it possible to conduct fully nonlinguistic tests of the Sapir-Whorf hypothesis, thus escaping the circularity of earlier Whorfian research (see Pullum 1991, cited under Anti-Whorfian Literature).

Lee, Penny. 1996. *The Whorf theory complex: A critical reconstruction*. Amsterdam: John Benjamins.

A historical overview and reanalysis of Whorf and his critics.

Lenneberg, Eric H. 1953. Cognition in ethnolinguistics. *Language* 29:463–471.

A critique of ethnolinguistic research in the first half of the 20th century, followed by an attempt to propose a more fruitful methodology for conducting Whorfian research.

Levinson, Stephen C. 2003. Language and mind: Let's get the issues straight! In *Language in mind: Advances in the study of language and thought*. **Edited by Dedre Gentner and Susan Goldin-Meadow, 25–46. Cambridge, MA: MIT Press.**

Reassessment of Whorfian arguments by an eminent anthropological linguist.

Schaff, Adam. 1973. *Language and cognition*. **Translated by Olgierd Wojtaswiewicz. New York: McGraw-Hill.**

Statement of the importance of linguistic relativity for philosophy and political theory.

Slobin, Dan I. 1996. From "thought and language" to "thinking for speaking." In *Rethinking linguistic relativity*. **Edited by John J. Gumperz and Stephen C. Levinson, 70–96. Studies in the Social and Cultural Foundations of Language 17. Cambridge, UK: Cambridge Univ. Press.**

An influential proposal for a moderate form of linguistic relativity.

Empirical Tests of the Whorfian Hypothesis

For years, the Whorfian controversy was fueled by a dearth of relevant empirical evidence. Although a large literature documented differences among the grammars and lexicons of the world's languages, these data are not sufficient to support Whorfian claims: In order to establish whether people who talk differently also think differently, it is necessary to show that linguistic differences correspond to different behavior on some measure of nonlinguistic cognition or perception. The circularity of Whorfian claims that were based on linguistic data alone drove many scholars to dismiss the Whorfian hypothesis as logically flawed and empirically unsupported. More than half a century after the deaths of Sapir and Whorf, however, methodological advances have given rise to a body of evidence supporting some version of linguistic relativity: Numerous aspects of cognition and perception appear to depend, in part, on aspects of people's linguistic experience. Cross-linguistic differences in grammatical or lexical patterns have been reported to influence mental representations in a variety of conceptual domains (e.g., Time, Space, Motion, Color). Debate continues about how to interpret these empirical data with respect to theories of language and mind.

TIME

Time is one of the conceptual domains Whorf analyzed in a controversial essay, in which he noted differences between the Hopi language and so-called Standard Average European languages and suggested that there must be corresponding differences in their speakers' concepts (Whorf 1956). Since then, time has become a frequent test bed for the Whorfian hypothesis. In particular, researchers have focused on how different languages use different spatial metaphors for time. Several studies suggest that people also think about time spatially, conceptualizing temporal order (Boroditsky 2001, Núñez and Sweetser 2006) or duration (Casasanto, et al. 2004) as predicted by the particular space-time metaphors found in their languages. Beyond influences of spoken language, other studies show that the orthography used by literate members of a culture can influence the way they conceptualize time (Casasanto and Bottini 2010; Fuhrman and Boroditsky 2010; Ouellet, et al. 2010; Tversky, et al. 1991).

Boroditsky, Lera. 2001. Does language shape thought? Mandarin and English speakers' conceptions of time. *Cognitive Psychology* **43.1: 1–22.**

The first experimental study showing that speakers of English and Mandarin Chinese interpret temporal expressions in language differently, suggesting that English and Mandarin speakers tend to use different spatial schemas to conceptualize events in time.

Casasanto, Daniel, Lera Boroditsky, Webb Phillips, et al. 2004. How deep are effects of language on thought? Time estimation in speakers of English, Indonesian, Greek, and Spanish. In *Proceedings of the 26th Annual Conference Cognitive Science Society, August 4–7 2004, Chicago, IL*. **Edited by Ken Forbus, Dedre Gentner, and Terry Regier, 575–580. Mahwah, NJ: Lawrence Erlbaum.**

By using psychophysical tasks with nonlinguistic stimuli and responses, this study provides the first evidence that speakers of different languages conceptualize time differently, even when they are not using language.

Casasanto, Daniel, and Roberto Bottini. 2010. Can mirror-reading reverse the flow of time? In *Spatial Cognition VII: International Conference, Spatial Cognition 2010, Mt. Hood/Portland, OR, USA, August 2010*. **Edited by Christoph Hölscher, Thomas F. Shipley, Marta Olivetti Belardinelli, John A. Bateman, and Nora S. Newcombe, 335–345. Berlin: Springer.**

Whereas cross-linguistic studies show correlations between writing habits and mental representations of time, this training study establishes a causal relationship between orthography and temporal concepts and shows that exposure to a new orthography can reverse the left-to-right spatial mapping of time in people's minds.

Fuhrman, Orly, and Lera Boroditsky. 2010. Cross-cultural differences in mental representations of time: Evidence from an implicit nonlinguistic task. *Cognitive Science* **34.8: 1430–1451.**

Evidence that the left-right mapping of time reverses between English and Hebrew speakers, consistent with the orthographies of these languages.

Núñez, Rafael, and Eve Sweetser. 2006. With the future behind them: Convergent evidence from Aymara language and gesture in the crosslinguistic comparison of spatial construals of time. *Cognitive Science* **30.3: 401–450.**

Evidence that speakers of Aymara, a South American language, gesture forward for the past and backward for the future, consistent with spoken metaphors in their language.

Ouellet, Marc, Julio Santiago, Ziv Israeli, and Shai Gabay. 2010. Is the future the right time? *Experimental Psychology* **57.4: 308–314.**

Evidence that the left-right mapping of time reverses between Spanish and Hebrew speakers, consistent with the orthographies of these languages.

Tversky, Barbara, Sol Kugelmass, and Atalia Winter. 1991. Cross-cultural and developmental trends in graphic productions. *Cognitive Psychology* **23.4: 515–557.**

The first study to show that people implicitly associate earlier times with the left and later times with the right of body-centered space, and that the direction in which time flows in their minds covaries with the direction of reading and writing in their language.

Whorf, Benjamin L. 1956. The relation of habitual thought and behavior to language. In *Language, thought, and reality: Selected writings of Benjamin Lee Whorf*. **Edited by John B. Carroll, 134–159. Cambridge, MA: MIT Press.**

Whorf argues, on the basis of the grammar and lexicon of Hopi, that Hopi speakers must have markedly different conceptions of time from speakers of "Standard Average European" languages.

SPACE

Spatial cognition is a frequent test bed for the Sapir-Whorf hypothesis. Several studies examine cross-linguistic differences in the use of spatial frames of reference and their effects on spatial reasoning (see Levinson and Brown 1994; Majid, et al. 2004 for Whorfian claims; see Li and Gleitman 2002 for counterargument). Related studies investigate how spatial words, such as "right" and "left," enable speakers of languages that have these terms available to navigate their spatial environment, using strategies that are unavailable to people and animals who lack these words (Hermer and Spelke 1994; Hermer-Vazquez, et al. 1999). Other studies test whether cross-linguistic differences in lexicalized spatial categories (e.g., "in," "on") correspond to differences in the way speakers of different languages conceptualize relationships between objects (Bowerman and Choi 2001; Hespos and Spelke 2004; McDonough, et al. 2003).

Bowerman, Melissa and Soonja Choi. 2001. Shaping meanings for language: Universal and language-specific in the acquisition of spatial semantic categories. In *Language acquisition and conceptual development*. **Edited by Melissa Bowerman and Stephen C. Levinson, 475–511. Cambridge, UK: Cambridge Univ. Press.**

Evidence that children learn to use different spatial concepts as they acquire languages that lexicalize different spatial relationships.

Hermer, Linda, and Elizabeth S. Spelke. 1994. A geometric process for spatial reorientation in young children. *Nature* **370:57–59.**

Evidence that, like animals, young children who lack use of the terms "left" and "right" are limited in their strategies for spatial navigation.

Hermer-Vazquez, Linda, Elizabeth S. Spelke, and Alla S. Katsnelson. 1999. Sources of flexibility in human cognition: Dual-task studies of space and language. *Cognitive Psychology* **39:3–36.**

Evidence that when the use of spatial terms like "left" and "right" is blocked, adults are limited in their strategies for spatial navigation, like children and animals. This study establishes a causal role for language in spatial reasoning.

Hespos, Susan J., and Elizabeth S. Spelke. 2004. Conceptual precursors to language. *Nature* **430:453–456.**

Evidence for spatial conceptual categories that precede language development.

Levinson, Stephen C., and Penelope Brown. 1994. Immanuel Kant among the Tenejapans: Anthropology as empirical philosophy. *Ethos* **22.1: 3–41.**

An argument against the universality of body-based frames of reference in language and thought.

Li, Peggy, and Lila Gleitman. 2002. Turning the tables: Language and spatial reasoning. *Cognition* **83:265–294.**

An experimental study on the basis of which the authors question earlier conclusions about the influence of spatial language on spatial reasoning.

Majid, Asifa, Melissa Bowerman, Sotaro Kita, Daniel B. M. Haun, and Stephen C. Levinson. 2004. Can language restructure cognition? The case for space. *Trends in Cognitive Sciences* **8.3: 108–114.**

A concise review of experiments testing the universality of spatial frames of reference in cognition.

McDonough, Laraine, Soonja Choi, and Jean M. Mandler. 2003. Understanding spatial relations: Flexible infants, lexical adults. *Cognitive Psychology* **46:229–259.**

Evidence that, although a range of spatial relational categories are available to infants, some of these categories become harder to use in adults whose language does not encode them.

MOTION

Across languages, syntax requires the same information to be packaged differently. Due to this syntactic packaging, information that is obligatory in one language may be optional in another. Slobin 1996 proposed that this should lead to differences in the way speakers of different languages experience the world and mentally represent their experiences, at least while they are using language (a proposal known as the "thinking for speaking" hypothesis, elaborated in Slobin 2003). The initial test bed for Slobin's proposal was the syntactic encoding of motion information. Whereas some languages focus speakers' attention on the path that people or objects travel (e.g., entering vs. exiting), others focus attention on the manner of motion (e.g., running vs. rolling; see Talmy 1991 for a full explanation of this linguistic distinction). Numerous studies have tested whether this difference has consequences for speakers' nonlinguistic mental representations of motion events. Some studies offer no support for the proposal that syntax influences "thinking for speaking" about motion events (Papafragou, et al. 2002). Other studies support the hypothesis (Choi and Bowerman 1991, Kita and Özyürek 2003), and investigate the circumstances under which this Whorfian effect is found (Gennari, et al. 2002; Papafragou, et al. 2008).

Choi, Soonja, and Melissa Bowerman. 1991. Learning to express motion events in Korean and English: The influence of language-specific lexicalization patterns. *Cognition* **41:83–121.**

Evidence that the languages children are exposed to can influence their mental representations of motion events.

Gennari, Silvia P., Steven A. Sloman, Barbara C. Malt, and W. Tecumseh Fitch. 2002. Motion events in language and cognition. *Cognition* **83:49–79.**

Evidence that grammar affects motion-event representations after people verbally describe the event, supporting a weak version of linguistic relativity.

Kita, Sotaro, and Aslı Özyürek. 2003. What does cross-linguistic variation in semantic coordination of speech and gesture reveal? Evidence for an interface representation of spatial thinking and speaking. *Journal of Memory and Language* **48:16–32.**

Reports cross-linguistic differences in the encoding of path and manner information in spontaneous co-speech gestures.

Papafragou, Anna, Justin Hulbert, and John Trueswell. 2008. Does language guide event perception? Evidence from eye movements. *Cognition* **108:155–184.**

An eyetracking study that provides insight into the time course over which event processing is affected by language.

Papafragou, Anna, Christine Massey, and Lila Gleitman. 2002. Shake, rattle, 'n' roll: The representation of motion in language and cognition. *Cognition* **84:189–219.**

Experiments that find no influence of grammar on event representation.

Slobin, Dan I. 1996. From "thought and language" to "thinking for speaking." In *Rethinking linguistic relativity*. **Edited by John J. Gumperz and Stephen C. Levinson, 70–96. Studies in the Social and Cultural Foundations of Language 17. Cambridge, UK: Cambridge Univ. Press.**

A statement of Slobin's original hypothesis about effects of motion language on event cognition.

Slobin, Dan I. 2003. Language and thought online: Cognitive consequences of linguistic relativity. In *Language in mind: Advances in the investigation of language and thought.* **Edited by Dedre Gentner and Susan Goldin-Meadow, 157–191. Cambridge, MA: MIT Press.**

A refinement of Slobin's hypothesis (see Slobin 1996, cited under Pro-Whorfian Literature).

Talmy, Leonard. 1991. Path to realization: A typology of event conflation. *Proceedings of the Annual Meeting of the Berkeley Linguistics Society* **17:480–519.**

Explains the linguistic basis for the proposed cross-linguistic difference in event representation.

NUMBER

The capacity to mentally represent exact numbers of objects larger than three or four appears to be uniquely human, and appears to depend in part on exposure to a counting system in language. Carey 2004 sketches a mechanism by which learning to count enables children to construct the concept of number, augmenting their innate cognitive capacities (see Rips, et al. 2006 for a counterargument). The role of language in the acquisition of number concepts has been tested in members of Amazonian tribes that lack extensive counting systems in their languages (Frank, et al. 2008; Gordon 2004; Pica, et al. 2004; but see Casasanto 2005). Especially compelling are tests of numerical cognition in deaf people who are members of numerate culture but do not know how to count (Spaepen, et al. 2011). Number is one cognitive domain in which claims for strong linguistic determinism are still viable: It appears that if people are not exposed to counting numbers in language, they do not develop cognitive capacities that most Western adults take for granted (e.g., the ability to distinguish six objects from seven). Beyond its role in the acquisition of number, it appears that language is used online as people perform mental arithmetic (Spelke and Tsivkin 2001).

Carey, Susan. 2004. Bootstrapping and the origin of concepts. *Daedalus* **133:59–68.**

A proposal that learning number words, initially as a meaningless word game, enables children to acquire number concepts.

Casasanto, Daniel. 2005. Crying "Whorf." *Science* **307:1721–1722.**

A critique of the methods and strong Whorfian conclusions of Gordon 2004.

Frank, Michael C., Daniel L. Everett, Evelina Fedorenko, and Edward Gibson. 2008. Number as a cognitive technology: Evidence from Pirahã language and cognition. *Cognition* **108:819–824.**

A study of the Pirahãs' numerical abilities that addresses some of the concerns raised about Gordon 2004 and clarifies the facts of the Pirahã number lexicon.

Gordon, Peter. 2004. Numerical cognition without words: Evidence from Amazonia. *Science* **306:496–499.**

A study claiming evidence for strong linguistic determinism, on the basis of experiments on the numerical abilities of the Pirahã, an Amazonian group with no words for exact numbers.

Pica, Pierre, Cathy Lemer, Véronique Izard, and Stanislaes Dehaene. 2004. Exact and approximate arithmetic in an Amazonian indigene group. *Science* **306:499–503.**

Evidence for a dramatic difference in numerical abilities between speakers of a language with a full counting list and speakers of a language with few number words.

Rips, Lance J., Jennifer Asmuth, and Amber Bloomfield. 2006. Giving the boot to the bootstrap: How not to learn the natural numbers. *Cognition* **101:B51–B60.**

An argument against the proposal in Carey 2004 that children use language to learn number concepts.

Spaepen, Eizabet, Marie Coppola, Elizabeth S. Spelke, Susan E. Carey, and Susan Goldin-Meadow. 2011. Number without a language model. *Proceedings of the National Academy of Sciences* **108.8: 3163–3168.**

Evidence that deaf people who are not exposed to number words as children do not acquire number concepts, despite living in a numerate society. This study strengthens the claim that language (as opposed to other aspects of culture) is crucial for the development of numerical cognition.

Spelke, Elizabeth S., and Sanna Tsivkin. 2001. Language and number: A bilingual training study. *Cognition* **78:45–88.**

Evidence of interactions between language and mental arithmetic.

COLOR

Some of the earliest attempts to test the Sapir-Whorf hypothesis used the domain of color as a test bed. Experiments have led to numerous conflicting pro-Whorfian and anti-Whorfian claims, sometimes by the same researcher analyzing different data sets (see Brown and Lenneberg 1954 and Brown 1976) or by different researchers analyzing the same data set (see Heider 1972 and Davidoff, et al. 1999). Debates continue about the extent to which color categories in language influence color categories in cognition and perception. A focus of debate has been the role of language in producing categorical perception of colors. Although the wavelength spectrum is continuous, mental color space appears to be divided into discrete categories, such that people are generally more efficient at discriminating colors across category boundaries than within a category (e.g., it is easier to distinguish a green dot from a blue dot than to discriminate two blue dots, even when the pairs of dots differ by the same number of wavelengths). Some scholars have argued that these category boundaries are universal (Berlin and Kay 1969). Yet experiments suggest that mental color boundaries are at least partly determined by language (see Kay and Kempton 1984; Özgen and Davies 2002; Regier and Kay 2009; Thierry, et al. 2009). The

conditions under which language influences color discrimination and the cognitive mechanisms by which language has its effects remain areas of active research.

Berlin, Brent, and Paul Kay. 1969. *Basic color terms: Their universality and evolution*. **Berkeley: Univ. of California Press.**

An ethnographic study that reduces all of the variability in the color vocabularies of the world's languages to eleven basic terms.

Brown, Roger. 1976. Reference in memorial tribute to Eric Lenneberg. *Cognition* **4:125–153.**

Brown completely renounces his earlier relativistic interpretation of Brown and Lenneberg 1954, arguing for a position of "universalism and linguistic insignificance" (p. 152), on the basis of subsequent research, including Berlin and Kay 1969 and Heider 1972.

Brown, Roger W., and Eric H. Lenneberg. 1954. A study in language and cognition. *Journal of Abnormal and Social Psychology* **49:454–462.**

Evidence that colors that are easier to name are easier to remember. Interpreted as evidence for linguistic relativity (but see Brown 1976).

Davidoff, Jules, Ian Davies, and Debi Roberson. 1999. Colour categories in a stone-age tribe. *Nature* **398:203–204.**

A reinterpretation of Heider 1972, which was a study of the Dani, and a replication of that study in another Papua New Guinean tribe, the Berinmo. A refutation of Heider's anti-Whorfian conclusion. This study led to numerous follow-up studies of the Berinmo, by these researchers and others.

Heider, Eleanor Rosch. 1972. Universals in color naming and memory. *Journal of Experimental Psychology* **93:10–20.**

Evidence of similarity in color naming and memory between English speakers and members of the Dani tribe of Papua New Guinea, whose language has only two color terms. Interpreted as evidence against previous linguistic relativity claims.

Kay, Paul, and Willett Kempton. 1984. What is the Sapir-Whorf hypothesis? *American Anthropologist* **86:65–79.**

A proposal and validation of a weak version of linguistic relativity, according to which effects of language on color perception should disappear when people are not using language (but see Thierry, et al. 2009).

Özgen, Emre and Ian R. L. Davies. 2002. Acquisition of categorical color perception: A perceptual learning approach to the linguistic relativity hypothesis. *Journal of Experimental Psychology: General* **131:477–493.**

Evidence that categorical perception effects can be induced through training. The authors propose and validate an account of how lexical color terms shape nonlinguistic color categories in the mind, via perceptual learning.

Regier, Terry, and Paul Kay. 2009. Language, thought, and color: Whorf was half right. *Trends in Cognitive Sciences* **13.10: 439–446.**

A concise review of studies showing effects of language on color judgments primarily for stimuli presented in the right visual hemifield, and therefore processed by the left hemisphere of the brain.

Thierry, Guillaume, Panos Athanasopoulos, Alison Wiggett, Benjamin Dering, and Jan-Rouke Kuipers. 2009. Unconscious effects of language-specific terminology on preattentive color perception. *Proceedings of the National Academy of Sciences* **106.11: 4567–4570.**

Using electrophysiological measures, the authors demonstrate language-specific sensitivity to color categories, providing the first clear evidence of influences of linguistic color categories on color perception; because the study used an implicit measure of unconscious

activity, it is not possible to explain this Whorfian effect based on strategic use of language.

OBJECTS

It may seem surprising that mental representations of concrete objects should be susceptible to influences of language, but this appears to be the case. According to many people's intuitions, our conceptualizations of things like puddles, pots, and ponies should depend solely on our perceptual experiences with these things, but several lines of research challenge this intuition. One set of studies investigates how grammatically marking a distinction between objects and substances influences people's construal of ambiguous stimuli (Lucy and Gaskins 2001, Imai and Gentner 1997; but see Barner, et al. 2010). Related studies investigate effects of nominal classifiers (i.e., particles that classify objects according to their shape) on object perception and categorization (Srinivasan 2010, Gao and Malt 2009). Still other studies examine effects of grammatical gender on people's concepts of inanimate objects. These studies suggest that using a masculine gender marker, such as the French "le" or a feminine marker like "la," can cause speakers to attribute more masculine or feminine qualities to inherently sexless objects like toasters and teapots (Boroditsky, et al. 2003; Sera, et al. 2002; Vigliocco, et al. 2005). The mechanisms by which these aspects of grammar affect object concepts, and the circumstances under which Whorfian effects can be observed, are still under investigation.

Barner, David, Peggy Li, and Jesse Snedeker. 2010. Words as windows to thought: The case of object representation. *Current Directions in Psychological Science* **19:195–200.**

A brief review and skeptical evaluation of studies suggesting that count/mass syntax influences people's object representations.

Boroditsky, Lera, Lauren A. Schmidt, and Webb Phillips. 2003. Sex, syntax, and semantics. In *Language in mind: Advances in the study of language and thought***. Edited by Dedre Gentner and Susan Goldin-Meadow, 61–79. Cambridge, MA: MIT Press.**

Evidence that grammatical gender affects people's conceptual representations of objects.

Gao, Ming Y., and Barbara C. Malt. 2009. Mental representation and cognitive consequences of Chinese individual classifiers. *Language and Cognitive Processes* **24:1124–1179.**

Extensive exploration of Chinese classifiers and of their observed and potential cognitive consequences.

Imai, Mutsumi, and Dedre Gentner. 1997. A cross-linguistic study of early word meaning: Universal ontology and linguistic influence. *Cognition* **62:169–200.**

Evidence that cross-linguistic differences in the count/mass distinction in grammar can influence children's categorization of objects and substances.

Lucy, John A., and Suzanne Gaskins. 2001. Grammatical categories and the development of classification preferences: A comparative approach. In *Language Acquisition and Conceptual Development***. Edited by Stephen Levinson and Melissa Bowerman, 257–283. Cambridge, UK: Cambridge Univ. Press.**

Evidence that cross-linguistic count/mass syntax influences adults' construal of objects and substances.

Sera, Maria D., Chryle Elieff, James Forbes, Melissa Clark Burch, Wanda Rodriguez, and Diane Poulin Dubois. 2002. When language affects cognition and when it does not: An analysis of grammatical gender and classification. *Journal of Experimental Psychology: General* **131:377–397.**

Evidence of effects of grammatical gender on categorization in Italian but not in German, and an exploration of these positive and negative findings using connectionist modeling.

Srinivasan, Mahesh. 2010. Do classifiers predict differences in cognitive processing? A study of nominal classification in Mandarin Chinese. *Language and Cognition* **2.2: 177–190.**

Evidence that nominal classifiers influence object processing in a visual search task.

Vigliocco, Gabriella, David P. Vinson, Federica Paganelli, and Katharina Dworzynski. 2005. Grammatical gender effects on cognition: Implications for language learning and language use. *Journal of Experimental Psychology: General* **134:501–520.**

Evidence that grammatical gender affects lexical semantics; the authors argue that their effects do not extend to nonlinguistic, conceptual representations.

COUNTERFACTUAL REASONING

Some languages, like Chinese, lack the subjunctive mood, which is used in other languages like English to express counterfactual scenarios (e.g., If it *were* to rain, then I would take an umbrella). Because counterfactuals are harder to express in Chinese than in English, Bloom 1981 posited that Chinese speakers would have more difficulty understanding counterfactual aspects of narratives than speakers of languages like English. Although this proposal appeared to be supported initially, Au 1983 challenged Bloom's claim, suggesting that Bloom's results were due to awkward translations, and providing experimental evidence that when tested in Chinese, Chinese bilinguals performed better on tests of counterfactual understanding than American subjects did when tested in English.

Au, Terry Kit-Fong. 1983. Chinese and English counterfactuals: The Sapir-Whorf hypothesis revisited. *Cognition* **15:155–187.**

A failure to replicate the finding in Bloom 1981 that Chinese speakers have difficulty understanding counterfactuals, and a refutation of his Whorfian claim.

Bloom, Alfred H. 1981. *The linguistic shaping of thought: A study in the impact of language on thinking in China and the West.* **Hillsdale, NJ: Lawrence Erlbaum.**

Initial evidence for Bloom's proposal that Chinese speakers have more difficulty with counterfactual reasoning than English speakers due to the lack of a subjunctive mood in Chinese.

THEORY OF MIND

Learning to use certain syntactic structures may help children develop theory of mind (i.e., the capacity to think about thinking and to understand what other people know, want, or believe). On one proposal, using complement clauses (e.g., he said *that the apple was an orange*) plays a special role in developing the capacity to reason about false beliefs (De Villiers and Pyers 1997, Lohmann and Tomasello 2003; but see Slade and Ruffman 2005). Another proposal suggests a similar effect of using evidential morphology. Evidential markers on verbs indicate the source of the speaker's knowledge (e.g., whether you saw something yourself or only heard about it from another person), and are obligatory in some languages, such as Turkish and Korean. The empirical record shows some results that suggest using evidential morphology may hasten the development of theory of mind (Papafragou 2002) and other results that challenge this proposal (Papafragou, et al. 2007).

De Villiers, Jill, and Jennie Pyers. 1997. Complementing cognition: The relationship between language and theory of mind. In *Proceedings of the 21st annual Boston University Conference on Language Development.* **Edited by Elizabeth Hughes, Mary Hughes, and Annabel Greenhill, 136–147. Somerville, MA: Cascadilla.**

Proposal that understanding complement clauses aids theory-of-mind development.

Lohmann, Heidemarie, and Michael Tomasello. 2003. The role of language in the development of false-belief understanding: A training study. *Child Development* **74:1130–1144.**

Evidence that aspects of the linguistic discourse, as well as elements of syntax, help children develop an understanding of false beliefs.

Papafragou, Anna. 2002. Mindreading and verbal communication. *Mind and Language* **17:55–67.**

Evidence that three-year-old children who speak Korean (a language with evidential markers) are more successful at false-belief tasks

than age-matched speakers of English (a language with no evidential markers), supporting a proposed role for evidential morphology in the acquisition of theory of mind.

Papafragou, Anna, Peggy Li, Youngon Choi, and Chung-hye Han. 2007. Evidentiality in language and cognition. *Cognition* **103:253–299.**

Experiments showing no difference in theory of mind abilities between Korean and English three-year olds, contradicting the results of Papafragou 2002.

Slade, Lance, and Ted Ruffman. 2005. How language does (and does not) relate to theory of mind: A longitudinal study of syntax, semantics, working memory and false belief. *British Journal of Developmental Psychology* **23:117–141.**

Evidence that both linguistic syntax and semantics contribute to theory of mind development.

CAUSATION

Across languages, there are different ways of describing causal relationships between actors and actions. In English, it is possible to say that *the key opened the lock*. In Korean and other languages, however, such a statement would sound strange because keys are inanimate and cannot cause locks to open without an animate agent (Wolff, et al. 2009; Wolff, et al. 2010). In Spanish, a common way to express the idea that *she broke the vase* would be *se rompió el florero*, literally "the vase broke itself" (Fausey and Boroditsky 2011). Such differences in the linguistic coding of causation appear to influence how speakers of different languages perceive and remember events and how people assign blame for the effects of people's actions (Fausey and Boroditsky 2010).

Fausey, Caitlin M., and Lera Boroditsky. 2010. Subtle linguistic cues influence perceived blame and financial liability. *Psychonomic Bulletin and Review* **17.5: 644–650.**

Evidence that manipulating agentivity in language can influence people's attribution of blame for accidental events.

Fausey, Caitlin M., and Lera Boroditsky. 2011. Who dunnit? Cross-linguistic differences in eye-witness memory. *Psychonomic Bulletin and Review* **18.1: 150–157.**

Evidence that speakers of different languages remember the same causal events differently. Implications for eyewitness memory are discussed.

Wolff, Phillip, Ga-hyun Jeon, Bianca Klettke, and Yu Li. 2010. Force creation and possible causers across languages. In *Words and the mind: How words capture human experience*. **Edited by Barbara C. Malt and Phillip Wolff, 93–110. New York: Oxford Univ. Press.**

A detailed exploration of the semantics of causation across languages and implications for how people perceive and understand causal events.

Wolff, Phillip, Ga-hyun Jeon, and Yu Li. 2009. Causers in English, Korean, and Chinese and the individuation of events. *Language and Cognition* **1:167–196.**

Experiments showing effects of the linguistic encoding of causation on people's judgments about events.

BACK TO TOP