the PSYCHOLOGY of LANGUAGE

an INTEGRATED APPROACH

DAVID LUDDEN

#10-04 Samsung Hub

Singapore 049483

Printed in the United States of America

Cataloging-in-publication data available for this title from the Library of Congress.

ISBN 978-1-4522-8880-2

This book is printed on acid-free paper.

15 16 17 18 19 10 9 8 7 6 5 4 3 2 1

Acquisitions Editor: Reid Hester

Digital Content Editor: Lucy Berbeo

Production Editor: Laura Barrett

Copy Editor: Lynn Weber

Typesetter: C&M Digitals (P) Ltd.

Proofreader: Kris Bergstad

Indexer: Will Ragsdale

Cover Designer: Gail Buschman

Detailed Table of Contents

Detailed Table of Contents

Preface

I got to psychology rather late in my career. From an early age, I'd had a driving curiosity about language. In school, English was always my favorite subject, and I took four years of French in high school. My interest in languages led me to a bachelor's degree in French and German, followed naturally by a master's degree in linguistics. During my Asia years, I picked up Japanese and two dialects of Chinese. In the meanwhile, I dabbled in a number of languages, working through beginning texts in Spanish, Russian, Latin, and Ancient Greek. Well into my thirties, I thought of myself as a linguist, a scholar of languages.

That all changed during my second year working on a PhD in linguistics at the University of Iowa. Just out of curiosity, I signed up for a Psychology of Language course offered way across campus. It was Gregg Oden who showed me the light (or turned me to the dark side, depending on whose version of the story you choose to believe). After taking Gregg's class, I finally knew what I wanted to be when I grew up—a psycholinguist!

The following year, I transferred to the psychology department at Iowa, where I benefited from the mentorship of many outstanding scholars. In particular, I'd like to thank my advisor Prahlad Gupta for putting up with my impertinence and bullheadedness on many an occasion while managing to teach me far more about the science of psycholinguistics than I had realized at the time. Thanks also to my other mentors at Iowa who guided me down a path that I have never regretted taking. These include Steve Luck, Shaun Vecera, Larissa Samuelson, and also Rochelle Newman, who is now at the University of Maryland.

My first job out of graduate school was at a small liberal arts college where I was half of the psychology department. As a result, I taught most of the psychology curriculum at one time or another, and it was this experience with a wide range of courses that turned me into a generalist. However, as I taught classes like Social Psychology or History and

Issues, in which I knew only marginally more about the subject matter than my students, I was repeatedly impressed by the importance of language in every area of psychology, even though it was rarely acknowledged by the scholars of those fields.

Like the air we breathe, language is often taken for granted. Yet language is every bit as vital for our human existence as oxygen. We cannot live without air, and we cannot live a fully human life without language. Philosophers may debate whether it's worse to lose the faculty of sight or the faculty of hearing, but blind people and deaf people still manage to lead happy and productive lives. The same simply cannot be said for those who've lost the faculty of language. These unfortunates are relegated to the sidelines of humanity, unable to take part in the most basic of human institutions—family, friendship, and community. Indeed, it's language above all else that defines us as a species.

This broad view of the role of language in human psychology is what I've attempted to portray in this book. I didn't want to just write another psycholinguistics textbook, as there are plenty of fine options available for the instructor who wants to take a traditional cognitive approach to the study of language processes. Instead, I wanted to write a book about the psychology of language that integrated all the major approaches of the field—including social, cognitive, evolutionary, biological, cultural, and developmental—into the discussion. This was my goal, although you the reader will be the one to judge how well I've succeeded at the task.

I wish to thank my colleague Morris Grubbs and my wife, Yawen, for convincing me, over a lunch of Thai curry, that I really could—and should—write this book. Likewise, I owe an immense debt of gratitude to my editor Reid Hester, who all along has had more faith in this project than I could ever muster. Without Reid imposing "impossible" deadlines—that I always somehow managed to meet—this completed textbook would still be lingering in the conceptual stage. The rest of the SAGE team has been wonderful as well. Thanks to Eve Oettinger, my initial contact at SAGE who passed my idea for a textbook on to Reid; to Sarita Sarak, who helped me put together my proposal; and to Nathan Davidson, for his insightful comments on the manuscript reviews.

Special thanks go to Lucy Berbeo for her diligence, persistence, and incredible detective skills. Lucy has taught me a lot about the nitty-gritty aspects of putting together a book.

On the homefront, I'd like to thank my children Jennifer and Jason, who as recent grads were able to give me a college-student perspective on portions of the text. I'd also like to thank my parents, Carol and David, for asking "So how's the book coming along?" every time we talked. Their confidence in my ability sustained me through hard times. Finally, I need to thank my wife Yawen again for all the emotional and material support she provided me during the two years it took to complete this project. Without her constant encouragement, I never could have written this book.

Publisher's Acknowledgments

SAGE gratefully acknowledges the contributions of the following reviewers:

Tamiko Azuma, Arizona State University
Natalie Kacinik, CUNY Brooklyn College
Anna B. Cieślicka, Texas A&M International University
Neal J. Pearlmutter, Northeastern University
Lydia Volaitis, Massachusetts Institute of Technology, Program in Writing and Humanistic Studies
Laura Sabourin, University of Ottawa
Ann R. Eisenberg, The University of Texas at San Antonio
Shannon N. Whitten, University of Central Florida
Stephani Foraker, SUNY Buffalo State
Daniel S. McConnell, University of Central Florida
Susan Baillet, University of Portland
Wind Cowles, University of Florida
Dirk-Bart den Ouden, University of South Carolina
Gretchen Sunderman, Florida State University
Jan Berkhout, Psychology Department, University of South Dakota
Usha Lakshmanan, Southern Illinois University Carbondale
Kathleen M. Eberhard, University of Notre Dame
Daniel S. McConnell, University of Central Florida
Annie J. Olmstead, SUNY New Paltz
Patrick Rebuschat, Lancaster University, Department of Linguistics and English Language
Daniel S. Koo, Gallaudet University

About the Author

David Ludden

is a professor of psychology at Georgia Gwinnett College near Atlanta. He considers himself a generalist, and he has taught a wide variety of psychology courses, including cognitive, physiological, evolutionary, social, and cross-cultural psychology as well as research methods and the psychology of language. Showing a penchant for languages from an early age, he majored in French and German as an undergraduate at Ohio University, where he returned, after a brief stint in Japan, to complete a master's degree in linguistics. Following a second, much longer stint in East Asia, he earned a PhD in cognitive psychology from the University of Iowa. His research extends far beyond his traditional psycholinguistics training to include a consideration the evolutionary, biological, developmental, and social factors that make all human languages so incredibly similar.

Chapter 1 Animal Communication and Human Language

Kanzi watched one of the keepers play the game with his mother. They did this most afternoons, and she often got cross with him during these sessions. But if he sat quietly on her shoulders, he could watch them. The keeper pointed at some colorful squiggles on a plastic sheet, and then Kanzi's mother was supposed to do the same. But she wasn't very good at the game, and she'd just made another mistake. Kanzi squealed and shook his finger, but they both ignored him.

It seemed to Kanzi that the keepers used the plastic sheet to communicate with. Sometimes he even thought he knew what they were trying to say and how his mother was supposed to respond. But she just didn't get it. The keepers also made noises to communicate with each other, but neither Kanzi nor his mother understood that.

One day during a session, another keeper came into the room. The two keepers squawked at each other, and then they led Kanzi's mother out of the room, leaving him behind. Kanzi climbed onto the table and started pointing at the squiggles on the plastic sheet. The patterns were easy, and he had no idea why his mother found them so difficult.

When one of the keepers returned, he traced out a pattern with his finger. She looked, and he did it again. The keeper traced a different pattern, and Kanzi gave the response. They did this several more times, and then the keeper scooped little Kanzi into her arms and laughed. Now laughter Kanzi understood—even bonobos do that.

From then on, Sue Savage-Rumbaugh and her colleagues focused their attention on Kanzi instead of his mother (Savage-Rumbaugh & Lewin, 1994; Savage-Rumbaugh, Shanker, & Taylor, 1998). In retrospect, it was obvious.

Human adults have difficulty learning a language, so why should they have expected more from an adult bonobo? Little Kanzi, however, picked up the symbol language quickly and could use it to communicate with his keepers. Later, he even learned to understand their speech, even though he couldn't speak himself.

Not all scientists agree that Kanzi has learned language. He may use words, they contend, but he doesn't understand syntax—the rules for combining words into sentences. And syntax, according to the traditional view, is what separates human languages from animal communication systems. Kanzi's understanding of syntax may be weak, others argue, but his ability to express novel ideas far exceeds anything that animals can do in the wild. Perhaps, then, Kanzi and other linguistically trained apes can tell us something about how our ancestors transitioned from a limited set of animal calls to the infinitely expressive communication system we call human language.

Section 1.1: Animal COmmunication Systems

- Animals use various communication systems to aid survival and reproductive needs; these usually center around foraging for food, avoiding predators, recognizing friends, and finding a mate.
- Honeybees perform a waggle dance to communicate with hive mates about the location of resources.
- Vervet monkeys vocalize to warn group members about three kinds of predators: leopards, eagles, and snakes; alarm calls lead to appropriate evasive action.
- Many social species use vocalizations to maintain social structure and to establish a dominance hierarchy; in this way, members understand their relationships with other members of the group.
- Animals use many means to attract mates; these include vocalizations, bright colors, and flashing lights.
- Animal communication systems:(1) have a limited range of meanings, (2) consist of holophrases that refer to an entire situation, (3) cannot combine elements to create novel ideas, and (4) can only refer to the current situation.

If you want to find a mate, you've got to advertise. This is certainly true in our digital age, but it's equally true in the animal kingdom. It's five o'clock in the morning, and there's a cardinal singing outside my bedroom window. Birdsong is the Facebook of the avian world.

That cardinal is simply playing the game of life, the whole point of which is to get your genes into the next generation. But before you can do that, you need to know four things: who you can eat, who wants to eat you, who is part of your group, and who you can mate with. An **ethologist**, that is, *a scientist who studies animal behavior*, often refers to these as the four Fs—food, foe, friend, and finding a mate.

Animals communicate with each other about the four Fs through a variety of means. We can define **communication** as *any behavior on the part of one organism intended to influence the emotions, thoughts, or behaviors of another organism*. Communication is often vocal, but it can also take the form of facial expressions, body postures, movements, odors—even flashing lights if you're a firefly. Most of this communication is directed at a **conspecific**, that is, *a member of the same species*, but interspecies communication happens as well, and so does interspecies eavesdropping (Lea et al., 2008; Magrath, Pitcher, & Gardner, 2009).

Food

The sun is streaming through my bedroom window, so I get up and dress for my morning run. I dash out the door and down the street. Along the side of the road is a patch of clover, and I see a honeybee flitting from blossom to blossom. She's a scout, foraging for nectar. But there are too many flowers in this patch for just one bee to harvest, so she lifts up and flies away. She's heading back to the nest to tell her hive mates what she's found, and she'll do this by means of a dance.

Austrian ethologist Karl von Frisch (1967) first deciphered the honeybee waggle dance in the mid-twentieth century. Scientists had long been aware of the bee dance, and they had also long suspected that bees somehow communicated about the location of resources, but it was von Frisch who finally put the two together.

When our honeybee returns to her nest, hundreds of hive mates will gather around her, and she'll perform a figure-eight dance. She'll start with a waggle-run, followed by a turn to the right to circle back to her starting point. Then she'll do the waggle-run again, this time circling back on the left. She may do this a hundred times or more as hive mates fly off to gather the nectar she has just told them about.

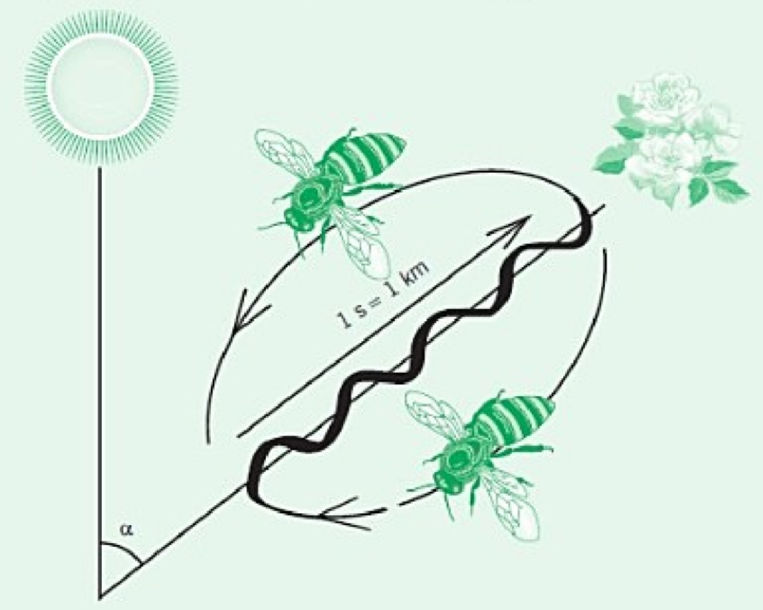
Through a series of experiments in which he systematically changed the location of a nectar source after a scouting bee had found it, von Frisch learned that the waggle dance gave hive mates two pieces of information: direction and distance. This dance is performed on the vertical surface of the honeycombs, and if the scout waggles straight upward, she is telling the others to fly in the direction of the sun. If she dances to the left or right of the vertical axis, she is telling them the angle from the sun in which they need to fly. She also tells her hive mates how far to fly, as the length of the waggle is correlated with the distance from the hive.

Thus, honeybees can communicate about two things, direction and distance to fly. Yet she can't tell them what they'll find when they get there. She could have been scouting for nectar, but bees need water too, and she could have been scouting for that. And if the hive is in the market for a new home, she might be bringing news about some prime real estate. But that much she simply can't tell, as animal communication systems are always quite limited in their range of expression.

Honeybees aren't the only animals to communicate about food sources. Some primate species vocalize when they find a new food source, and these food calls will evoke foraging behaviors among other members of their group (Kitzmann & Caine, 2009). In the case of honeybees, the evolutionary advantage of food communication is clear. In a honeybee colony, just the queen bee reproduces, and her daughters can only get their genes into the next generation if the queen survives and mates. But birds and mammals are generally in competition with other members of their group for food (and mates), so the purpose of food calls is less clear. Perhaps they're helping family members, who share their genes. But some ethologists suspect that food calls are less about communicating a food source than they are vocalizations of unrestrained excitement at finding a tasty treat (Clay, Smith, & Blumstein, 2012).

Figure 1.1 Honeybee Waggle Dance

Honeybees perform a dance to tell hive mates about the location of sources of nectar or water. They communicate two pieces of information: the direction relative to the sun and the distance. The hive mates know where to fly, but they don't know what they'll find when they get there.



Source: © Audriusa / Wkimedia Commons / CC-BY-SA-3.0 / GFDL.

Foe

My morning run takes me across the campus lawn, graced with hundred-year-old oaks and pines. A squirrel scampers about, gathering food. She sees me approach and rears up on her hind legs. And then she chatters, drops the acorn in her paws, and scampers up a tree. Her chattering is what is known as an **alarm call**. Many social species use such *a vocalization to warn other members of the group about approaching predators*. But American red squirrels are solitary creatures, and ethologists are still not sure why they make alarm calls (Digweed & Rendall, 2009, 2010). They might be warning relatives in nearby trees, or they may be directing the call at the predator, as if to say, "I see you."

Better understood is the system of alarm calls used by vervet monkeys in Africa (Seyfarth, Cheney, & Marler, 1980a, 1980b). Vervets are a social species living in groups of up to seventy individuals, and they spend their days foraging for food. Vervets have three enemies: leopards, which want to eat them; eagles, which can carry off their young; and snakes, whose venomous bite can kill them. Avoiding each of these foes requires a different strategy, and vervets have a different call for each predator. When a vervet sees a leopard and makes the "leopard" call, all the other members of the group scamper up the nearest tree. When the "eagle" call is made, they scamper under the nearest bush or overhanging rock. And when the "snake" call is made, they look down and watch carefully where they tread.

Seyfarth, Cheney, and Marler (1980a, 1980b) deciphered this system first by careful observation and then by experimentation. They recorded what they suspected were "leopard," "eagle," and "snake" calls, and then they played them back through speakers hidden in trees. Sure enough, the vervets reacted as expected based on the type of call that was played. So it appears that vervets have a "language" consisting of three words. And like human languages, this communicative behavior is partially innate and partially learned. For example, young vervets at first will use the "leopard" call for just about any four-legged mammal (just as a young human will call just about any four-legged mammal "doggie"), but mother vervets will punish mistakes, and the young ones quickly learn.

Figure 1.2 Vervet Monkeys

Vervet monkeys use alarm calls to warn other members of their group about predators.

Source: © AiStockphoto.com / Laitho.

The call system of Diana monkeys, close relatives of the vervets, has been systematically studied as well (Zuberbühler, Cheney, and Seyfarth, 1999). Diana monkeys make two different alarm calls, one for leopards and one for eagles, their two main predators. The researchers used a prime-probe task to evaluate the meaningfulness of these alarm calls. In the baseline condition, they played a recording of an eagle vocalization (the prime) and measured the number of alarm calls per minute for the next six minutes. After six minutes, they played the eagle vocalization again (the probe), but this time the vocalization elicited no new alarm calls. In the test condition, they played a recording of an eagle alarm call, and the monkeys responded with more eagle calls. But six minutes later, when the researchers played an eagle vocalization, the monkeys did not respond. In the control condition, the researchers played a leopard alarm call, which elicited more leopard alarm calls. Six minutes later, the researchers played an eagle vocalization, which this time elicited eagle vocalizations. They also repeated the three conditions, swapping eagle and leopard alarms and vocalizations. In this way, the researchers were able to determine that the alarm calls referred to specific predators and not to danger in general.

Compared with human languages, monkey talk is extremely limited. To start with, they only have two or three words. And moreover, monkey words can't be used in as wide a range of contexts as human words. To a vervet or Diana monkey, the "leopard" call means "leopard here and now," and never, "I saw a leopard yesterday down by the river." Nor could a monkey use the "eagle" call to say, "If you see an eagle, keep a close eye on the kiddies." Monkey alarm calls, like animal communication systems in general—and specifically unlike human language—are stuck in the here and now.

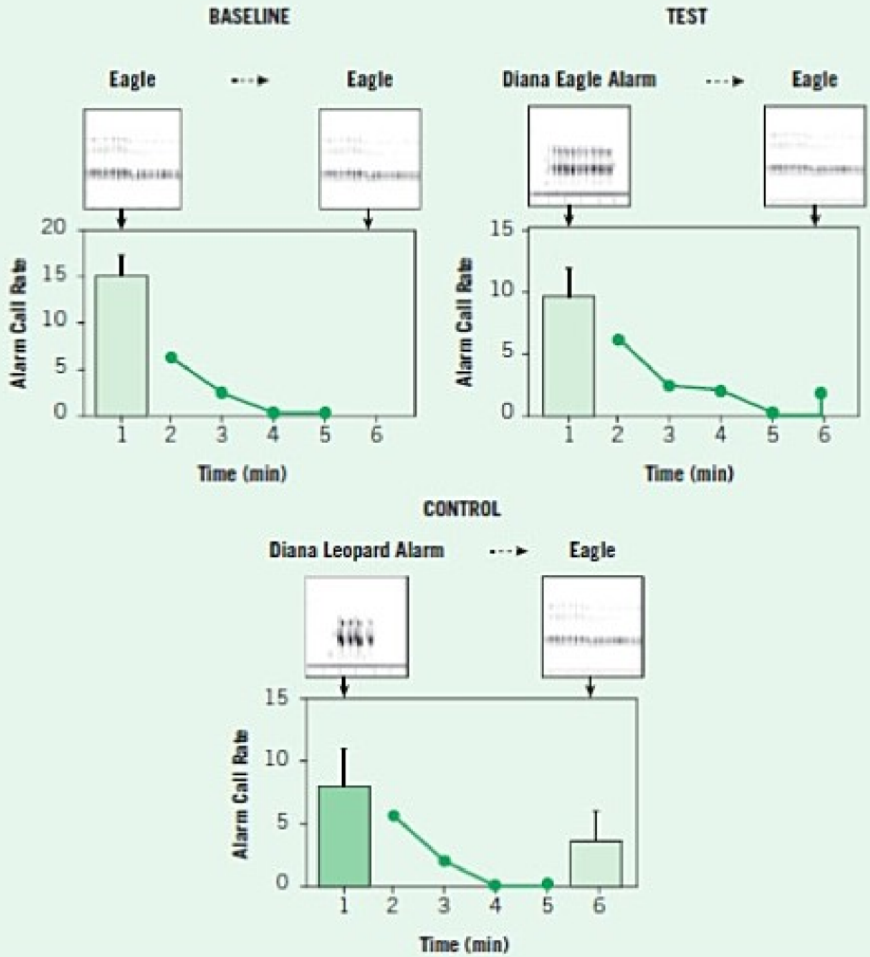
Friend

My morning run next takes me out a country lane, past a herd of cattle grazing in a field. One cow moos, and then another. Cattle express a variety of emotional states through vocalizations, but one reason they vocalize is to maintain social structure within the herd. Like other social species, cattle herds are structured according to a **dominance hierarchy**, *a social system in which each member of a group knows who ranks above and who ranks below*. Vocalizations are one way these relationships are acknowledged (Hall et al., 1988; Watts & Stookey, 2000). Furthermore, cows and calves use vocalizations as part of the attachment process, and calves separated from their mothers just two weeks after birth can still recognize their mother's voice three weeks later (Barfield, Tang-Martinez, and Trainer, 1994).

Vocalizations are an important aspect of mother-infant bonding in a wide variety of species. For example, rat pups that have fallen out of the nest will emit high-pitched whines (Brunelli, Shair, & Hofer 1994). These ultrasonic calls are above the range of human hearing, and presumably that of most predators as well; but rat moms can hear them, and when they do, they search for their lost little ones and bring them back to the nest. Human infants likewise make high-pitched whines that bring their mothers running for them. And, like cow and calf, human mom and baby will often exchange vocalizations that clearly have positive emotional value for both.

Figure 1.3 Eagle and Leopard Alarm of the Diana Monkey

Zuberbühler, Cheney, and Seyfarth (1999) tested the meaningfulness of alarm calls in Diana monkeys using a prime-probe task. In the baseline condition, monkeys were primed with an eagle vocalization, and alarm calls per minute were counted for the next six minutes. This was followed by an eagle vocalization probe, which elicited no more alarm calls. In the test condition, the monkeys were primed with an eagle alarm call and probed with an eagle vocalization, yielding results similar to the baseline condition. In the control condition, the monkeys were primed with a leopard alarm call and probed with an eagle vocalization. This time, the probe elicited additional alarm calls. In this way, the researchers were able to determine that the alarm calls referred to specific predators and not to danger in general.



Source: Zuberbühler (2005).

The social role of vocalizations in our closest cousins, the chimpanzees and bonobos, is not well studied (Zuberbühler, 2005). However, **social grooming** has been widely studied in these species, and it is clear that in the primate world, friendships are built through *the practice of picking fleas and dirt from the fur of conspecifics* (Fedurek & Dunbar, 2009). Although it may seem a stretch to count social grooming as communication, it is behavior intended to influence the emotion and behavior of other organisms, and so it fits our definition. We'll visit the practice of social grooming again in our discussion of the evolution of language in Section 1.3.

Finding a Mate

I've finished my morning run, and as I walk across my front yard, I see the cardinal that was singing earlier. He's still at it. You eat, you avoid predators, you make friends, and then you find a mate—that's how the game of life is played. And through the entire game, animals are communicating with each other.

You only have to open your ears to hear the hustle and bustle of the animal world competing for the opportunity to put their genes into the next generation. And under no circumstances is animal communication rowdier, flashier, or more elaborate than when it's about sex. The peacock unfurls his feathers for every peahen he fancies. On a warm summer night, the bullfrog croaks in his pond, and the firefly lights up his tail, all in the hopes of attracting a female (Akre & Ryan, 2010; Stanger-Hall, Lloyd, & Hillis, 2007).

Humans play the same game of life. We eat our meals, fight our enemies, spend time with our friends, find someone special to settle down with, and raise a family. And to accomplish these tasks, we use language to communicate with each other. Many of us seem to be talking through all our waking hours, and when there's no one around, we talk to ourselves—sometimes out loud, sometimes in our head.

General Features of Animal Communication Systems

Although we use human language to achieve all the same goals that animal communication systems do, there are also some fundamental differences between the two. First, animal communication systems always have a very limited range of expression. Bees can communicate about the direction and distance to a resource, but they can't tell what that resource is. Vervets can warn other members of their group about an approaching predator—if it's a leopard, eagle, or snake. But they can't talk about anything else.

Second, an utterance in an animal communication system is always a **holophrase**, in other words, *a single vocalization or gesture that refers to the entire situation and not to the specific objects and events in that situation*. That is, the vervet "leopard" call really means something like, "Look out, there's a leopard coming this way!" and the "snake" call something like, "Yikes, I just saw a snake in the grass!"

Human toddlers start their language development with holophrases as well. "Ball!" can mean "Give me the ball!" or "Look, there's a ball!" And "No!" means something like, "I don't want that!" Even human adults, under emotional duress, often resort to holophrases. The reaction of most humans to a snake in the grass is not much different from that of a vervet monkey: "Snake! Ahh!"

Third, animal communication systems generally lack the ability to combine symbols together to express novel ideas. It is still a matter for further research what a vervet would say if it encountered both a leopard and a snake at the same time, but we just don't see vervets combining symbols to express novel ideas. The honeybee dance does complicate this issue somewhat. Each honeybee dance will be different, because each time the distance and direction will different. Still, honeybees have no ability to express any sort of meaning beyond that. It's this ability to combine symbols to express novel ideas that gives human language its expressive power, and how this is accomplished is the topic of Section 1.2.

Finally, we can point out one last hallmark of animal communication systems, namely that they are always about the here and now. A vervet "eagle" call is about an eagle flying overhead at this very moment, and not about an eagle the vervet saw last week. When a cow says "moo," she's saying, "Here I am, right now," and not, "See you down by the water trough in half an hour." Again, honeybee dance complicates the picture, since she's telling her hive mates about a resource she found some distance away some time ago. But still, she's talking about a distance a bee can quickly fly, and presumably the resource is still there now.

Much of human language is also communication about the present time and place: “What’s up?” “Not much.” “Hey, watch out for that truck!” But human language also allows us to escape the confines of the here and now to talk about the past, to think about the future, to wonder what’s happening on the other side of the planet, and to imagine times and places that never existed.

In Sum

Five million years ago, our ancestors split with those of the chimps and bonobos (Bradley, 2008). Sometime after that, language evolved. Modern humans started making their mark on this world within the last hundred thousand years, probably at about the same time that human language became fully formed. This powerful new tool for communicating—as well as thinking—allowed humans to transcend the limits of animal life, to bend nature to our will. And then in the blink of an eye, in evolutionary terms, language transported us from the Stone Age to the Space Age.

Review Questions

1. Ethologists say there are four basic categories animals must understand to survive and reproduce. What are they? Give an example of an animal communication system relevant to each of these categories.
2. Describe the honeybee communication system. Explain how von Frisch deciphered it.
3. Describe the vervet monkey communication system. Explain how Seyfarth and colleagues deciphered it.
4. What are the four characteristics of animal communication systems that make them different from human language?

Thought Questions

1. Chimpanzees live in complex social groups in which they build friendships, forge political alliances (in which they jostle for

position within the dominance hierarchy), and engage in cooperative hunting and warfare. How are they capable of accomplishing all this without language?
2. Imagine you were suddenly transported to a remote village where no one spoke English and you didn't speak their language. How would you communicate your needs to these people? Likewise, imagine you have joined a cloistered community and taken a vow of silence. How will you be able to cooperate with the other members if you can't talk with them?
3. The scenarios in the previous question involve the loss of language as a communication tool. But we also use language for thinking. Brain damage can lead to aphasia, or a total loss of language abilities. Presumably, these patients cannot use language to think with, either. (They can still use other means for thinking, though.) What would life be like if you could see and hear, but you could not use language even for thinking? How is such a condition different from ordinary existence for a chimpanzee?

Google It! Honeybee Waggle Dance

There are plenty of videos and articles on the Internet about animal communication systems. Try googling **bee dance** or**waggle dance, vervet monkey alarm call** (or just **alarm call**), and **mating call.**

Section 1.2: Human Language

- Laughter is a social vocalization we share with chimpanzees; we use it together with conversation to enhance social interactions.
- Language bears three important features as a communication system: (1) it is governed by rules, (2) it consists of structured components, and (3) it makes use of arbitrary symbols. Certain animal communication systems share some, but not all, of these features.

- Language is conveyed in three different modes: (1) in a vocal mode, which we call spoken language or speech; (2) in a manual mode, which we call signed language; and (3) a visual mode, which we call writing. By far, the vocal mode is most common.
- Duality of patterning gives language its expressive power; it is a process that takes units at a lower level and combines them according to rules into new units at a higher level. By repeating this process many times, a multilayered structure of great complexity can be built out of a small set of simple elements.
- The building blocks of language are phonemes, which are meaningless speech sounds. Phonemes combine to form morphemes, which are the basic units of meaning. Morphemes combine to form words, words combine to form phrases, phrases combine to form sentences, and sentences combine to form discourse.
- While animal communication systems are always about the here and now, human languages allow us to talk about events happening in other times and places; this is known as displacement.

In humans, language hasn't simply replaced the vocalizations of our primate cousins. Rather, we use language on top of the communication system we inherited from our prelinguistic predecessors. We laugh with joy, cry with despair, shriek with terror, shout with anger. And when we are overcome with emotion, our language faculty shuts down altogether, leaving us with nothing but our animal vocalizations and facial expressions. Because their body forms are somewhat different from ours, chimpanzees do not share all of the same vocalizations and facial expressions we have, and they even have some we don't. But there is one emotional expression widely found in the primate world that is uncannily similar in humans and chimps, and that is laughter (Davila-Ross et al., 2011; Palagi & Mancini, 2011; Vettin & Todt, 2005).

Laugh, and the World Laughs With You

Laughter isn't just the fare of comedy clubs and late-night TV; it's an integral part of our social communication. We laugh so frequently and so automatically that we’re often but vaguely aware we’ve done so and have no idea why. In fact, our very intuitions about why we laugh are completely wrong. Most of the time when we laugh, we do so not because someone said something funny, but simply because they said something, and we’d like them to say more (Mehu & Dunbar, 2008). We laugh to say, “I like you.” In other words, it is a kind of social vocalization, not unlike the mooing of cows in a herd.

Laughter evolved from the labored breathing of rough-and-tumble play, but it’s come to mean playful intent in both chimpanzees and humans (Provine, 2004). We punctuate our conversations with laughter, and by so doing, we encourage our conversation partners to stay in the chit-chat game. Chimpanzees likewise use short bursts of laughter during social interactions, and they’ll mimic the laugh patterns of those they are engaging with, presumably to promote social cohesion (Davila-Ross et al., 2011). In short, both species use laughter as a tool for building friendships.

In humans, there is a clear gender difference in laugh production (Provine, 2004). By far, women do most of the laughing, and men do most of the laugh-getting. It seems that laughter is part of the mate attraction process in humans. Human females laugh in the presence of males they find attractive, and the more a woman laughs during an encounter with the opposite sex, the greater is her reported interest in that man. Whether female chimpanzees use laughter to signal sexual interest is still an open topic for research.

Laughter and language bear an interesting relationship. Each involves the same vocal apparatus, and so you can’t do both at the same time, even though they are almost always used in the same context. Rather, in conversational interactions we alternate between talking and laughing, using laughter as a sort of punctuation between phrases and sentences (Provine, 2004). Even listeners usually wait until the end of the speaker’s sentence to laugh.

While it isn’t likely that language evolved out of laughter, differences between the way humans and chimpanzees laugh suggest something about what was needed for language to evolve. When chimpanzees laugh, they typically produce one long “ha” per breath. But humans have much greater control over their breathing, which they need for producing speech, and they typically produce a series of short bursts—“ha-ha-ha”—with each breath.

Speech! Speech!

In our modern world, human language can take several forms. For the most part, we use language in its spoken form, or speech. Speech is the form of human language that, at least on the surface, most resembles the vocalized communication systems of our primate cousins. But communities of the deaf use human languages in a manual mode, which we call signed languages. Primates in laboratory settings have been taught to use simplified signed languages, but they don't use them in the wild. Over the last few thousand years, we've devised ways to represent language in a visual mode, and we call this writing. It's important to note that signed languages are not just manual versions of spoken languages, but rather they are full-fledged languages in their own right. Furthermore, writing is not just a visual representation of speech, but rather it has taken on its own forms and conventions to fit the medium.

Nevertheless, speech is the primary form of human language. For millennia, speech was the only form of language, and even in today's world of near-universal literacy, we listen and speak far more than we read or write. Likewise, the users of signed languages are but a small fraction of a society that is dominated by spoken language users.

For this reason, in this textbook we'll emphasize the **primacy of speech**, that is, *the observation that virtually all language use is in the spoken mode* (Hockett, 1960). We'll do this in spite of the fact that much of the psycholinguistic research we will look at has studied language in its visual mode. It's much easier to present stimuli to research participants in a visual mode rather than in an auditory mode, and so most of the classical studies in psycholinguistics involved written language, with researchers working under the assumption that their findings would extrapolate to speech as well.

Rules, Structure, and Arbitrary Symbols

Laughter is a typical example of animal communication. It's holistic in expression, emotional by nature, and referential to the current situation. Language is also a form of communication, but it's quite different from anything seen elsewhere in the animal kingdom.

Defining language is difficult, but we've been avoiding it for too long, so let's take a stab at it. First, language is a communication system governed by rules. But even this definition doesn't completely get at the uniqueness of human language. Even animal communication systems have rules. You can't just make the "leopard" call whenever you feel like it, as every young vervet soon learns.

Second, language is a communication system consisting of structured components. Again, this doesn't uniquely specify human language. Even the honeybee waggle dance consists of components that are organized in a structure, in that the returning scout must structure her dance so that the length of the waggle correlates with the distance to the source, and the direction of the waggle correlates with the direction to fly.

Third, many language researchers claim that a key feature of language is the **arbitrary symbol**. That is, a word is *a symbol that bears no resemblance to what it refers to*. This observation is generally true of human languages. The word we use in English to refer to that furry, four-legged creature we keep as a pet is *dog*, but in Chinese it's *gǒu*, and in Japanese it's *inu*. And yet we also have onomatopoeia, which are words that sound like what they refer to, such as the *moo* of cows or the *woof-woof* of dogs. But even onomatopoeia differs from language to language. In Chinese, for example, cows go *móu* and dogs go *wàng-wàng*.

Each component of the honeybee waggle dance, on the other hand, is an **iconic symbol**, meaning it's *a symbol that bears a clear resemblance to what it refers to*. The longer the dance, the longer the distance. Likewise, the greater the angle from the vertical, the greater the angle from the sun. Yet vervet alarm calls, as far as we know, are arbitrary. At least, there's nothing obvious, to human observers, in the relationship between the call and the predator it's referring to.

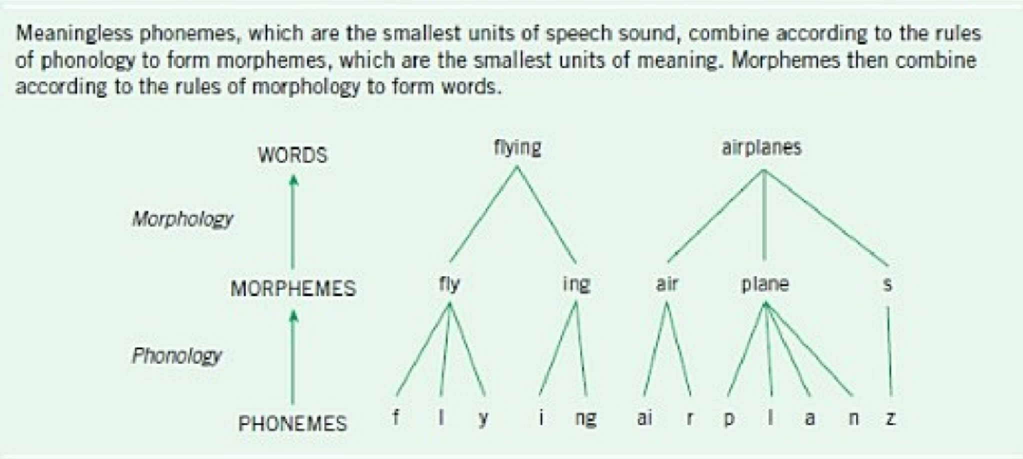
Table 1.1 A Rose by Any Other Name . . .	
"What's in a name? that which we call a rose by any other name would smell as sweet." So wrote William Shakespeare in *Romeo and Juliet*. Below is the name for ROSE in ten different languages. Notice that the word is similar across the various European languages because of borrowing. Outside of Europe, the name varies considerably. (The source for some of these items is from the Bab.la Online Dictionary, available at http://en.bab.la.)	
Chinese	méigui
Czech	růže
Finnish	ruusu
Hindi	gulaab
Hungarian	rózsa
Indonesian	bunga mawar
Japanese	bara
Spanish	rosa
Swahili	waridi
Turkish	gül

We want to make the case that human language is somehow unique. And yet it shares each of its three of its major features—rules, structure, and arbitrary symbols—with other animal communication systems. What makes human language unique is the combination of these three features into a complex system that linguists call **duality of patterning** (Hockett, 1960). This is *a structuring process that takes units at a lower level and combines them according to rules into new units at a higher level*. Furthermore, by repeating this process to build layer upon layer like a pyramid, languages can take a handful of simple elements (whether speech sounds, hand gestures, or squiggles on a page) and turn them into structures of exquisite complexity. Duality of patterning gives language users the ability to express virtually anything and likewise to think virtually anything. It's exactly this power of language that has lifted us out of the animal world in a few tens of thousands of years.

Pyramid Scheme

Standard American English (SAE) is just one of the many thousands of languages that's been spoken over the eons of human existence, and as far as languages go, it's pretty ordinary. At its most basic level, SAE is composed of about forty **phonemes**, which are *meaningless speech sounds that serve as the fundamental building blocks of language*. For example, the name of the language, English, is composed of six phonemes, namely*i-ng-g-l-i-sh.* The letters we use to write English attempt to represent the phonemes of the language, but we borrowed the alphabet from the Romans, and it's not a good fit. So don't be thrown off by double-letter combinations like *sh* that represent a single phoneme.

Figure 1.4 Duality of Patterning



Stand-alone phonemes are meaningless. We would never say "ng" in English —it just doesn't mean anything. We do under certain circumstances say "sh," and it does have a definite meaning, but it's more like one of those animal communication signals we still use—it's holistic, emotional, and referential to the current situation. Anyway, "sh" has no meaning when it occurs as a phoneme in "English" or any other word. As we said, SAE has an inventory of about forty phonemes, which is fairly typical for a human language.

According to the principle of duality of patterning, units at a lower level are combined by rules into units at a higher level. *The set of rules for combining phonemes into larger units* is called **phonology**. We learn these rules implicitly as youngsters. Any native speaker of English can tell you that *glunt*, *obligrate*, and *thessily* are possible words in the language, even though they don't happen to be actual words. On the other hand, sequences such as *zwckl*, *brznsk*, and *uioeaaio* are not even possible words in the language. But the rules of phonology do differ somewhat from language to language. For example, speakers of Japanese are baffled that English speakers hear *street* as a single syllable, which to them sounds like the five-syllable sequence *su-to-re-e-to*, based on the rules of Japanese phonology. On the other hand, the Japanese word for "moon," which is *tski*, is hard to pronounce as a single syllable for native speakers of English.

The rules of phonology take the lower level units, the phonemes, and combine them into units at the next higher level. These units are called **morphemes**, and they represent *the basic units of meaning in a language*. Some morphemes can stand alone as words, and these are called free morphemes. Other morphemes cannot stand alone but rather must be combined with other morphemes to form words, and these are called bound morphemes. Bound morphemes are the prefixes and suffixes we attach to words.

In some languages, like English and Chinese, many words consist of a single free morpheme. Consider the following example English sentence and its Chinese equivalent.

English: I want to go, but I have no money.

Chinese: *Wǒ yào qù, dàn wǒ méi yǒu qián.*

'I want go, but I not have money.'

In both cases, each word consists of a single morpheme. That is to say, there is no way to divide any of the words into parts that are also meaningful.

Still, both English and Chinese make use of bound morphemes, in the form of suffixes and prefixes. Sometimes bound morphemes are there strictly for the grammar and add little or no meaning. One example is the *-s* suffix on verbs, as in the sentence:

Malcolm want-s to come to the party, and I want to also.

Due to the quirky history of English, this relic from an ancient form of the language is still hanging around vexing native speakers, who are often perplexed about when it's needed and when it's not.

English has other bound morphemes that serve a more reasonable grammatical function. All verbs can take the *-ing* suffix indicating that the action is ongoing, and all regular verbs can take the *-ed* suffix indicating that the action happened in the past, as in the sentence:

We were play-ing Guitar Hero when Kyle bump-ed his head.

All English nouns can take the *-'s* suffix indicating possession, and all regular English nouns can take the *-s* suffix indicating plural. And when a noun is both possessive and plural, the suffix is *-s'*, as in the sentence:

Miriam-'s boy-s' bicycle-s are blocking the driveway.

Notice that while the three suffixes are distinguished in writing by the strategic use of an apostrophe, in speech all three sound exactly the same, and that's why English writers are so confused in their use.

The set of rules for combining morphemes together to form words is called **morphology**. English and Chinese morphology are relatively simple, but it can be quite complex in some languages. One such language is Japanese, at least in the case of verbs, which consist of a verb root that can almost never stand alone, followed by one or more suffixes indicating various grammatical distinctions. My favorite is *ik-ase-rare-na-katta*, which means "I was not caused to go."

The important thing to notice in this discussion of morphemes, morphology, and words is that we once again see duality of patterning. Just as phonemes combine according to the rules of phonology to form morphemes, morphemes combine according to the rules of morphology to form words. It's this repeating pattern of units at a lower level combining according to rules to form units at a higher level—in other words, duality of patterning—that gives human language such power of expression.

Sentences and Discourse

Human language is built in a hierarchical structure, layer upon layer, with this same duality of patterning linking adjacent levels. In the simple view, words combine according to rules to form sentences, but in fact there is an intermediate step. Words first group themselves into phrases, and these phrases then group themselves into sentences. *The set of rules for ordering words and phrases into sentences* is called **syntax**. If we want to be more precise about the rules ordering words first into phrases and then into sentences, we mention phrase structure rules.

When we consider phrase structure rules from a cognitive psychology perspective, it's clear why we need two stages to go from words to sentences. It has to do with working memory constraints. If we think of **working memory** as *a kind of short-term memory that holds whatever we are currently thinking about*, and if we keep in mind that working memory has a very limited capacity—generally considered to be around seven items—we can see that many sentences exceed this capacity in terms of number of words. But we can only talk about what we're currently thinking about; likewise, we can only understand what someone is saying if we can hold it in working memory long enough to process it. So if we went straight from words to sentences, we'd have to keep our sentences short.

Classical cognitive psychology teaches us that we can increase working memory capacity through a process known as **chunking**, which is *a process that groups meaningless items into larger meaningful units in order to increase working memory capacity*. (This should sound suspiciously like duality of patterning.) For example, if I tell you (and I'll be lying) that my office phone number is 207-834-0880, chances are you won't be able to remember it. But if you are a student on my campus, you'll know that 207 is the local area code and that 834 is the campus prefix. You can chunk these, leaving enough room in working memory to hold the four random digits of my office extension. And so it is when we go from words to sentences.

If the idea of phrase structure is still unclear to you, let's consider for a moment the following totally random sentence:

The man in the Santa Claus suit used to be my history professor.

Imagine you're going to pause somewhere in this sentence, perhaps to laugh. You'll probably do it this way:

> The man in the Santa Claus suit [hah, hah] used to be my history professor.

This is the most natural way to break this sentence because what comes before the laugh is a single unit, namely the subject of the sentence. It's what the sentence is about. The string of words following the laugh is also a single unit, namely the predicate. The predicate makes some kind of comment about the subject. Generally speaking, that's what we do when we talk—we point something out, and then we make a comment about it.

It's possible to insert laughter at other places in the sentence. For example, you could also laugh here:

> The man [hee, hee] in the Santa Claus suit [hah, hah] used to be my history professor.

We can do this because the subject phrase of this sentence is complex, consisting of the noun phrase *the man* and the prepositional phrase *in the Santa Claus suit*. Furthermore, if you're feeling especially giggly, you could even laugh here:

> The man [hee, hee] in the Santa Claus suit [hah, hah] used to be [ho, ho] my history professor.

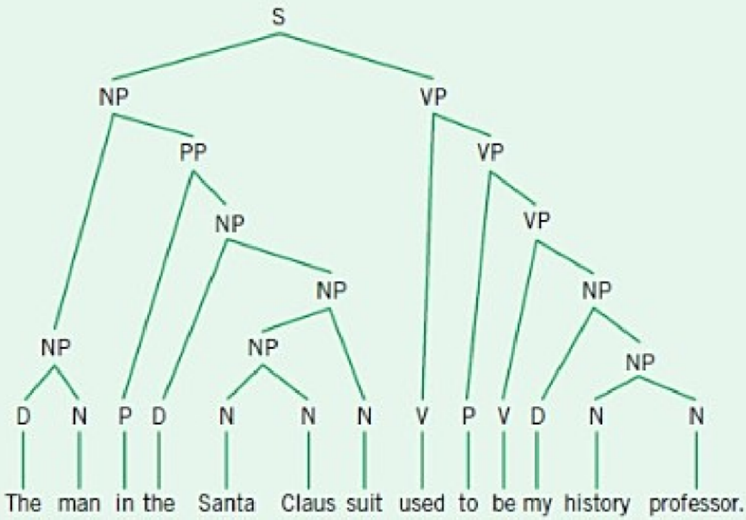
The predicate phrase is also complex, consisting of the verb phrase *used to be* and the object noun phrase *my history professor*.

Linguists like to illustrate the hierarchical structure of sentences by means of tree diagrams. Each branch in a tree diagram represents an instance of duality of patterning, units at a lower level combining to form a unit at the next higher level.

Traditionally, linguists have viewed the sentence as the basic unit of language. In fact, most of the linguistic research of the last half of the twentieth century focused on teasing out the structure of sentences, following the lead of noted linguist Noam Chomsky. However, people just don't go around uttering random sentences. Instead, they utter sentences within larger linguistic structures, such as conversations and narratives. These are examples of **discourse**, which is *a language structure consisting of a sequence of sentences that are ordered according to rules*. Conversations have rules for taking turns and changing topics. And narratives, or stories, have rules for how events need to be ordered. We implicitly learn the rules of discourse as we grow up, and we are all aware of violations of these rules, even though we can rarely articulate them. Any careful analysis of a conversation or a story will reveal duality of patterning once again as the structuring agent.

Figure 1.5 Sentence Tree

Tree diagram for the sentence: "The man in the Santa Claus suit used to be my history professor." Note the various instances of recursion in the structure, especially the nesting of noun phrases within noun phrases and verb phrases within verb phrases. Abbreviations: D = determiner, N = noun, P = preposition, V = verb, NP = noun phrase, VP = verb phrase, PP = prepositional phrase, and S = sentence. (We will discuss recursion in Section 1.3.)



Long, Long Ago, in a Galaxy Far, Far Away...

Before we end this section, we need to briefly discuss one other feature of human language that distinguishes it from animal communication systems. We have already seen that animal communication is about the here and now. Human communication, even with language, is also to a great extent about the here and now. However, embedded within the complex hierarchical structure of language are devices that allow us to escape the confines of the eternal present. Because we have so many words, we can use some of them to indicate that we are talking about past events or future events or even hypothetical events, and furthermore those events could have happened at some other place than where speaker and the listener currently are, perhaps down by the river, or on the other side of the boulder, or even in some place that we only imagined.

The ability to refer to things and events beyond the here and now is called **displacement**. We have already seen in the case of the honeybee waggle dance that some animal communication systems also exhibit limited displacement. Nevertheless, the complexity of human language allows for displacement on a far grander scale than is capable in any other communication system. Furthermore, it is this power of displacement in human language that allows us to think in terms of hypothetical situations, to consider alternative worlds—and what we would need to do to make them reality.

In Sum

It is the hierarchical structure of human language that lends it such expressive power. The ability to combine meaningless sounds into meaningful words allows for a vocabulary of unlimited size, and the ability to combine words into sentences allows for the expression of complex ideas. Although we often use language for the same purposes as animal communication systems, language also supports complex thought processes, and it also allows us to efficiently convey information from one human to another and from one generation to next. In sum, language is the single attribute that makes us uniquely human.

Review Questions

1. What is the evolutionary origin of laughter, and how is it used in chimpanzees and humans? What is the relationship between laughter and language? What insight into the evolution of language is provided by a comparison of chimpanzee and human

laughter?
2. Rules, structure, arbitrary symbols, and displacement are all features of human language. Explain what is meant by each feature. For each feature, also give an example of an animal communication system that exhibits that feature.
3. What is duality of patterning? Explain this process in terms of phonemes, morphemes, and phonology. What happens next?
4. Explain the organization of words into phrases and sentences in terms of working memory constraints.
5. What is discourse? What are the two main types of spoken discourse? How are they similar? How are they different?

Thought Questions

1. Why is laughter contagious? Laughter evolved from the labored breathing of rough-and-tumble play, but what is the relationship between play and language?
2. Linguists and psychologists maintain that signed languages have all the features of spoken languages, and in fact both signed and spoken languages are processed in the same regions of the brain. But what would be the phonemes and morphemes of a signed language?
3. Besides modality, what are some differences between spoken and written languages? What circumstances in the way the two are used can account for these differences?
4. Duality of patterning is not just a phenomenon of human languages. In fact, it is a structuring principle that is also found in the physical and biological worlds as well as in the structure of human societies. Can you think of some concrete examples?

Google It! Chimpanzee Laughter

There are plenty of video clips about **chimpanzee laughter** on YouTube. You can also find out something in common between the way chimpanzees and human babies laugh.

Section 1.3 Evolution of Language

- Humans and chimpanzees share a common ancestor; *Homo erectus* was an ancestor of both the Neanderthals and modern humans.
- Recursion, or the process of extending a pattern by placing it inside itself, is an important feature of human language in particular and human thought in general.
- The question of whether human language evolved gradually or rapidly is known as the continuity debate; both continuity and discontinuity theories have been proposed.
- Evidence for discontinuity theories includes (1) the specific language impairment of the KE family, (2) the FOXP2 gene, and (3) the disparity between animal communication and human language.
- Evidence for continuity theories includes (1) the fact that these theories are consistent with the principles of natural selection, and (2) the existence of pidgins, which suggests the possibility that pre-humans spoke a protolanguage halfway between animal calls and full language.
- Social theories of language evolution emphasize (1) the special nature of mother–infant interactions, (2) the relationship between music and speech, or (3) the role of conversation in building and maintaining social relationships.

A great king of India once invited six blind monks to his palace to examine an elephant. The first blind monk placed his hands against the side of the elephant and declared, “This is a wall.” The second grabbed the elephant’s ear and said, “This is a fan.” The third had the elephant’s tail and called it a snake. The fourth held the elephant’s trunk and said it was a tree limb. The fifth said the smooth, pointed tusk was a sword. And the last one, wrapping his arms around one of its legs, said he’d found a pillar. The six blind monks commenced fighting among themselves until the king ordered them to stop. “You are all right," said the king. "And you are all wrong."

This story is an apt parable for the endeavor of science. We believe there's something called reality out there, but each of us has only the faintest glimpse of it. We must remember to always be humble and not to assume that we know all there is to know, as did the blind monks in the parable. Instead, we need to keep in mind that what we know is only our current best guess as to the true nature of the world. And furthermore, we have to always remember that other people have different insights from our own. Neither our view nor theirs is totally correct, but rather the truth lies somewhere in between. As scientists, we need to collect as much evidence as we can, fill in the blanks with reasonable assumptions, and keep an open mind to the fact that, as new evidence comes to light, our understanding of the world will change. It is with this open, humble frame of mind that we recount the natural history of our species and the role in it played by our most wonderful invention, language.

Out of Africa

Our home is in Africa. Our chimpanzee cousins still live there, as do many of our human siblings. But others of us spread out through the world until we covered every continent except snow-capped Antarctica. The story goes back five million years, but first we need to understand something about **speciation**, or *the processes involved in the evolution of new species*.

A common metaphor for evolution is a ladder. According to this view, we humans are higher up the evolutionary ladder than are the chimpanzees. But this view is inappropriate. Instead, a better metaphor for evolution is a tree. The tree of life is three billion years old, with branches upon branches upon branches, and the leaves on the tips of those branches are the species currently in existence.

Species do not evolve from one form to another as they ascend the ladder of evolution. Rather, populations that were once a single species split in two, and as these two groups go their separate ways, they each adapt to their new environments and thus evolve into different species. One way to determine whether two populations are one or two species is to see if they can interbreed. Humans from the various continents of the world can (and frequently do) interbreed, so we can say all humans belong to one species. On the other hand, dogs and cats cannot interbreed, and so they are clearly separate species.

Humans did not evolve from chimpanzees. Rather, humans and chimpanzees have a common ancestor about five million years ago (Bradley, 2008). After the split, various pre-human species arose and then disappeared, as species have been doing since life began on this planet. Sometimes several species of pre-humans existed at the same time, perhaps even competing for the same territory and resources. This is not surprising. After all, there are two species of chimpanzee—the common chimp and the bonobo—living not far apart from each other back on the African homestead. Indeed, there's something very suspicious about the fact that there's only one living human species today, especially given that other human species once shared this planet with our ancestors.

The first important human ancestor for our story is *Homo erectus*, which arose in Africa about 1.8 million years ago (Disotell, 2012). *H. erectus* was the first human-like creature to walk truly upright. The members of this species lived in hunter-gatherer societies, used fire and stone tools, and probably had a communication system more complex than the vocalizations of our chimp cousins but still not nearly as complex as the full language of modern humans (Bickerton, 1990). They were similar in height to modern humans, though stockier, and they had a cranial capacity much larger than modern chimpanzees but still somewhat smaller than that of modern humans. Dressed in modern clothes, a member of *H. erectus* riding the New York subway might not catch anyone's attention.

By all accounts, *H. erectus* was a successful species. Its members were fruitful and multiplied, and some of them migrated from the African home base, eventually occupying large swaths of Europe and Asia, reaching all the way to China and Southeast Asia. But then, around 200,000 years ago, the fossil record on *H. erectus* fizzles out (Ben-Dor et al., 2011; Disotell, 2012). Still, a million and a half years is a pretty good run for a species. Incidentally, 200,000 years ago is about the time *Homo sapiens*—us!—begins to appear in the fossil record. Before we look at our own history, though, let's briefly consider our sibling species, the Neanderthals.

There are no fossil remains of *Homo neanderthalensis* in Africa, only in Europe and Asia. From this we can only guess that the Neanderthals branched off from those members of *H. erectus* that had already left Africa. The earliest Neanderthal fossils date to 400,000 years ago (Hublin, 2009). They were somewhat larger and stronger than modern humans, and their brains were slightly larger as well. They too used fire and tools, and they lived in hunter-gatherer societies. There really is no reason to think that they did not have a communication system at least approaching the sophistication of our modern language (Wynn & Coolidge, 2012).

Our branch of the family, *Homo sapiens*, has its origins in Africa around 200,000 years ago, and by 50,000 years ago we see clear signs of stone-age culture. Like our *erectus* forebears a million and a half years before us, we too were fruitful and multiplied, and we began the second wave of human migration out of Africa. Our *erectus* ancestors had already died out, but we met our Neanderthal cousins in Europe 40,000 years ago. For 10,000 years, two species of humans lived side by side, but then the Neanderthals died out—under rather suspicious circumstances.

Some scientists think we killed them (Banks et al., 2008). Perhaps it was outright warfare between the two species of humans, or perhaps it was a competition for resources. But for some reason, the Neanderthals—with their bigger brains and stronger bodies—were no match for us. As a psycholinguist, I prefer to think that perhaps we had more fully developed language than they did, and that's what gave us the edge. But then I'm just a blind monk holding a part of an elephant.

Other scientists believe we made love, not war, with the Neanderthals (Smith, Janković, & Karavanić, 2005). According to this theory, when our ancestors, coming out of Africa, met with the Neanderthals in Europe, we recognized members of the same species, and we interbred with them. In fact, there is some evidence of Neanderthal ancestry in the DNA of people of European descent. If this theory is true, there really are Neanderthals riding the New York subway!

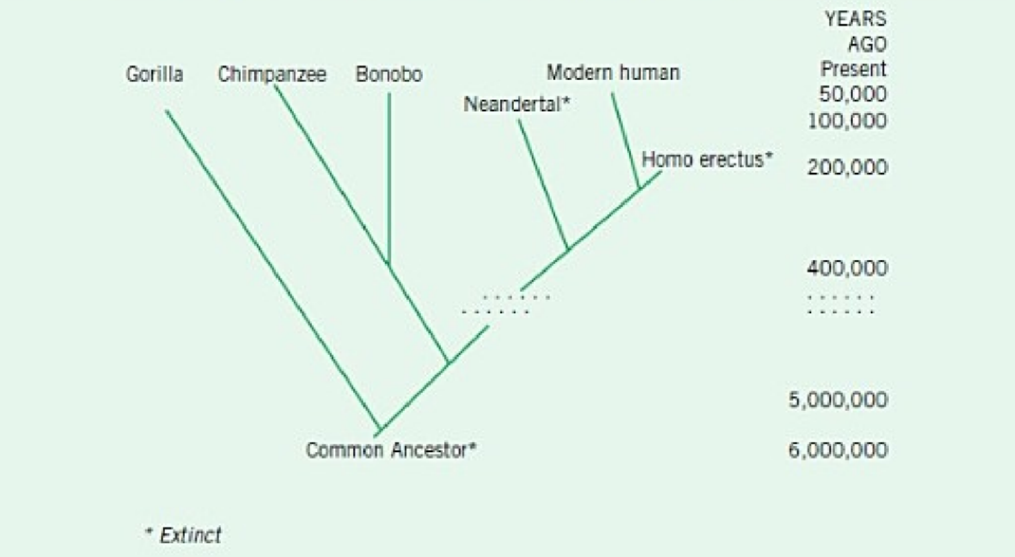
Hopeful Monster

Timmy and Tommy are having a counting contest. "One," says Timmy. "Two," says Tommy. "Three," Timmy replies. "Four," Tommy responds. Timmy pauses. He can't think of a higher number, and neither can Tommy. Of course, counting contests are pointless. As any grade school pupil can tell you, no matter how high you count, there's always a higher number. Mathematicians put it this way: for any n, there is $n + 1$. This property of numbers is known as recursion.

Put simply, **recursion** is *the process of extending a pattern by placing it inside itself*. When we count, we know that the next number is one more than the last number, or as mathematicians put it, $n_1 = n_0+1$. Recursive patterns occur widely in nature, from the structure of DNA to the number of petals on a daisy. Likewise, recursion is a feature of many of our day-to-day behaviors, for example, when we wash, rinse, and repeat.

Figure 1.6 Lineage of Modern Humans and Related Species

Approximate family tree for the hominid lineage. Species marked with an asterisk are considered extinct. Note that the dates are approximate. Estimated dates for the branching of gorilla and chimpanzee from the common ancestor vary by several million years; the dates given in this figure are based on Bradley (2008).



Recursion is a characteristic of human languages as well. Just as there is no such thing as a highest number, there is no such thing as a longest sentence. Children pick up on the recursive nature of language even before they enter grade school, and they play language games in which they challenge each other to extend sentences indefinitely. *I saw the dog . . . that chased the cat . . . that caught the rat*. . . . And so on. In this game, you extend the sentence by tacking on an additional relative clause at the end. However, unlike a counting contest, this game is a memory challenge. The sentence never has to end, but eventually your memory for repeating it will fail, and then you're out of the game.

According to linguist Noam Chomsky (2011), recursion is the key to understanding how human languages evolved from more primitive communication systems. Chomsky leads a school of linguistics that emphasizes the **centrality of syntax**. This is *the view that the ability to organize words into phrases and sentences according to recursive rules is the distinguishing feature of language*. If this is the case, then what evolved first was not language but rather an understanding of recursion. Once the ability to think recursively was hardwired into our brains, Chomsky argues, language in its full form naturally emerged.

Figure 1.7 Recursion in Russian Dolls

A set of Russian dolls, known as *matryoska*, provides a concrete example of recursion. Each doll resembles the others, but one fits inside another, those inside a third, and so on. Likewise in language, we can nest sentences inside each other. This is a unique aspect of human language as a communication system.

Source: © iStockphoto.com / BomBeR_irk.

Many animal species, including human babies, have a simple number sense

(Xu, Spelke, & Goddard, 2005). That is, they can distinguish sets of two items from sets of three items or sets of four items. But they usually do not show an understanding of relationships among numbers, such as that three is greater than two but less than four. Nor do they understand counting as a recursive pattern.

Generally speaking, evolution proceeds incrementally. For example, a complex eye evolves, through countless steps, from a patch of light-sensitive skin (Land & Nilsson, 2002). At every step in the process, this "partial eye" provided a survival and reproductive advantage to those who had it, and so it was passed on to future generations. But Chomsky argues that language did not evolve this way. Instead, he proposes that a single mutation transformed the pre-human brain into a recursive thinking machine and that this mutation spread quickly through the population in one or a few generations (Hauser, Chomsky, & Fitch, 2002). In other words, our species was quickly transformed from one that communicated with grunts and gestures to one that spoke in complete sentences.

Chomsky's ideas on language were influential for much of the last half of the twentieth century. Still, his theory of language evolution is not without its detractors. Evolutionary biologists in particular question *the idea that a single mutation could lead to a rapid transition from one form to another*, calling it a **hopeful monster hypothesis** (Theißen, 2006). In general, *the question of whether human language evolved gradually or rapidly* is known as the **continuity debate**.

A Language Gene?

Chomsky's argument is philosophical, not empirical. That is to say, he presents his case based on logic and not on scientific evidence. He doesn't claim to know which gene has mutated, only that one must have. In the late twentieth century, though, it looked as though there might indeed be a language gene after all.

In 1990, linguist Myrna Gopnik (1990) reported on the so-called **KE family**, *an extended family living in London that exhibits a language disorder appearing to have a genetic cause*. Some members of the family exhibit an extreme form of **specific language impairment**, which is *a language processing and production disorder that cannot be attributed to other causes* *such as brain damage or hearing loss*. By tracking the occurrence of specific language impairment in members of the family through three generations, researchers were able to isolate the responsible gene, known as FOXP2. Family members with normal language abilities had the normal version of the FOXP2 gene, and those with specific language impairment had a defective version of the gene.

FOXP2 is *a gene found widely among vertebrates that plays a role in brain development as well as serving other functions*. In songbirds, for example, a mutation of the FOXP2 gene leads to disruptions in the ability to learn song (Bolhuis, Okanoya, & Scharff, 2010). Furthermore, newborn mice with a disrupted FOXP2 gene exhibit an alteration or absence of the ultrasonic vocalizations they use to call for their mother when they fall from the nest (Shu et al., 2005), leading these researchers to propose that FOXP2 plays a role in social communication across a wide variety of species.

In the end, FOXP2 is probably not the language gene Chomsky proposed. While it is true that chimpanzee FOXP2 is different from the human, it's also not the disrupted version found in the KE family (Konopka et al., 2009). Rather, it seems that a disruption of human FOXP2 leads to language impairments, just as a disruption of songbird FOXP2 leads to difficulties in learning birdsong (Bolhuis et al., 2010).

In fact, this discussion about the role of FOXP2 provides a good lesson in the proper way to think about genetics. Genes code for the production of proteins, which can have cascading effects both during embryonic development and the entire lifespan of the organism. FOXP2 influences not only the development of neural structures but also the cartilage and connective tissue of the face, all of which are important for spoken language but which serve other functions as well. In other words, there is no single "language gene," but instead our ability to speak is likely influenced by many genes that also subserve other functions besides language (Bolhuis et al., 2010).

Perhaps Chomsky has only described one part of the elephant. That is, while recursion is an important characteristic of human language, perhaps it's not the sole distinguishing feature. Instead, it's far more likely that human language evolved gradually from simple animal communication systems to its present complex form (Pinker & Bloom, 1990). Along the way, each addition to the communication toolkit of our early ancestors provided them with reproductive advantage, and thus the development of language was driven by the same forces of natural selection that we see at play throughout the natural world.

Continuity theories, which are *theories that propose a steady transition from animal communication systems to human language*, also have problems. First, there are no species alive today that display communicative skills between those of animals and humans. Indeed, this fact is taken as evidence for **discontinuity theories**, which are *theories that propose a sudden transition from animal communication systems to human language*.

Second, there is no way to tell for sure, just by looking at the fossils and artifacts of ancestral humans, what sort of communication system they had. Perhaps members of *Homo erectus* already had full language a million years ago, and they sat by the campfire at night telling each other stories. Or maybe the reason their culture stalled at campfires and rock tools was precisely because they had no effective means of communicating and thus transmitting culture. On the other hand, there is evidence from living human populations to suggest that human language does indeed come in incremental forms.

Long Time No See

When British traders arrived in southern China in the eighteenth century, no one on board spoke Chinese, and no one on land spoke English. Yet each had what the other wanted—the British offering silver and gold, and the Chinese offering tea and porcelain—so they had to find a way to communicate. They did this by developing a **pidgin**, which is a*simple language consisting of a few hundred words and a very basic grammar*, and it was just good enough to get the business done (Bolton, 2002). (In fact, it's believed that the word "pidgin" comes from the Chinese pronunciation of the English word "business.") Although this pidgin is no longer in use, several of its expressions, such as *long time no see* and *no can do*, have made their way into the English language.

Throughout history, whenever two human populations speaking different languages have come into extended contact with each other, the speakers of those two languages have developed a pidgin for the purpose of basic communication. It's important to note that pidgins are not languages by design, but rather they emerge naturally through the repeated interactions of humans who do not speak each other's language.

Although every pidgin is unique, they share some common features (Holm, 2000). They all have a limited vocabulary and a simple phonology, so the words are easy to pronounce and distinguish from one another. Pidgin syntax typically allows for simple subject-verb-object sentences but doesn't provide for the recursion necessary to build the complex sentences typical of full-fledged human languages. Thus, the expressive power of pidgins stands somewhere between the holophrases of animal language and the complex expressions of human language.

This observation has led linguist Derek Bickerton (1990, 2009) to propose that *Homo erectus* probably spoke a sort of pidgin. Since this was the only language they had, he calls it protolanguage to distinguish it from the general meaning of the term pidgin, which refers to a supplemental communication system used by people who already speak a full language. In other words, **protolanguage** is *a hypothetical pidgin-like language spoken by ancestral humans.* Pidgins can be an effective means of communication, and so if *Homo erectus* did have protolanguage, it would certainly have given the species an edge over other pre-human populations. And *Home erectus* was a very successful species, spreading across three continents during its tenure on this planet.

At first glance, the protolanguage hypothesis appears to propose a two-step program from animal communication to human language. As such, it's still a discontinuity theory with all the weaknesses of Chomsky's proposal. Yet two observations from living species suggests the transition from animal communication to protolanguage, and then from protolanguage to full language, may not be as abrupt as first imagined.

First, attempts to teach language to chimpanzees have shown that they are capable of learning pidgin-like communication systems, even though they have not developed these spontaneously in the wild. Thus, our ancestors may have been poised to acquire at least some aspects of language, and maybe all it took was a little nudge, perhaps some small reorganization of the brain, for them to develop protolanguage spontaneously.

Second, when children grow up in an environment where all the adults around them speak a pidgin, they develop a **creole**, which is *a full-fledged language based on a pidgin.* Thus, the transition from pidgin to creole only takes one generation, but of course this is with children who already have an innate understanding of recursion, as well as all the biological machinery necessary for language.

The “living fossils” of pidgins and creoles will be the topic of Section 1.4, but for now let’s review a few other current theories on language evolution.

Hush, Little Baby, Don’t You Cry

Kids say the darndest things, and so do mothers. Moms coo to their babies, and the babies coo back. It doesn’t matter what mom actually says—after all, the kid doesn’t understand any of it. Rather, it’s how she says it that counts. **Motherese**, or *the type of language caregivers use to interact with their infants*, is quite different from ordinary speech. (Since it’s not just mothers but caregivers in general who use this type of language, motherese is also known as caregiver speech or infant-directed speech.) The range of pitch is greater, the rhythms are more regular, and there’s plenty of repetition. In other words, motherese has a number of features in common with music.

Several theorists have looked at the connections between motherese and music and the evolution of language. For example, anthropologist Dean Falk (2009) has proposed that language evolved out of the vocalizations of mothers soothing their young. The **mother tongue hypothesis** is *a model of language evolution proposing that maternal vocalizations took on meaning over the course of many generations, developing into a way for family members to communicate*. After even more generations had passed, these mother tongues spread through communities until everyone in the group spoke the same language.

Archaeologist Steven Mithen (2005) proposes that it wasn’t motherese per se but rather singing that became the origin of speech. There is clearly a relationship between language and music, but the exact nature of that relationship is unclear, and scholars debate at length about which came first (Ross, 2009). Mithen claims that pre-human mothers made humming sounds to soothe their babies. Over evolutionary time, these wordless songs were segmented into meaningful units that became the words of language. Likewise, the habit of singing to babies was extended to other situations, such as religious ceremonies and to coordinate group behaviors. This idea, called the **singing Neanderthal hypothesis**, is *a model of language evolution proposing that both music and language derive from the same source, the humming of pre-human social interactions*. It’s important to note here that Mithen uses the term Neanderthal loosely, using it to refer to early humans in general and not just the species *Homo neanderthalensis*.

Also considering the social aspects of language is evolutionary psychologist Robin Dunbar (1998). Our chimpanzee cousins live in relatively complex societies, and they build and maintain social relationships through mutual grooming. Although grooming serves a hygienic purpose, cleaning the fur and skin of insects and debris, it also solidifies friendships. Humans also engage in social grooming—doing each other’s hair, primping each other’s clothes. But according to Dunbar, we’ve found an easier and more effective way of building and maintaining relationships—idle chit-chat. Thus, the **social grooming hypothesis** is *a model of language evolution proposing that gossip for humans serves the same purpose of social network building as does grooming for chimpanzees.*

These three hypotheses focus on the social aspects of language use and don’t really get at the specifics of how language evolved. But they do challenge us to think about what language really is. Traditional approaches, such as the one taken by Chomsky, view language as a system for transmitting thoughts from one person to another. Certainly, language does have that function, as for example when your professor lectures in class. Although you would prefer your teachers to speak in an engaging manner, what’s most important is content. Yet two friends will chit-chat for hours, and when they part ways the only thing engraved in their memories is that they had a great time, even though they can’t remember the details of what they talked about. In other words, it’s not the content that’s important but rather the communication of feelings, that is, the building of mutual trust and affection. Chit-chat with friends is a lot like motherese—it’s not so much what you say but how you say it that counts.

Figure 1.8 Photo of Baboons Engaged in Social Grooming

Baboons, like many primate species, live in groups and groom each other as a way of developing social relationships. Some scientists think social grooming may be an evolutionary precursor of language.

Source: © iStockphoto.com / mrtom-uk.

In Sum

There are a number of theories of language evolution, all of which have some support. Discontinuity theories focus on the disparity between animal communication and human language, proposing a sudden evolutionary shift to explain this observation. Continuity theories are more in line with the principles of natural selection, but they have a difficult time explaining the gulf between animal and human communicative abilities in the present. Social theories of language evolution emphasize the role of language in building and maintaining relationships, but they do not explain why such a complex system as language is necessary for achieving this goal.

Review Questions

1. Describe the evolutionary history of humans. What is our relationship with chimpanzees? What is our relationship with

Neanderthals?
2. Explain Chomsky's hopeful monster hypothesis. What is the evidence for and against it?
3. Explain the continuity debate. What is the evidence for and against the continuity and discontinuity hypotheses?
4. Explain how research on the KE family led to the discovery of the FOXP2 gene. Why is it not likely to be a "language gene" after all?
5. What is a pidgin, and under what circumstances does one develop? What is a creole, and under what circumstances does one develop? What is Bickerton's concept of protolanguage, and how does it relate to pidgins?
6. Describe each of the three social theories of language evolution presented in this section: (1) the mother tongue hypothesis; (2) the singing Neanderthal hypothesis; and (3) the social grooming hypothesis.

Thought Questions

1. A friend of yours asks: "If humans evolved from monkeys, why haven't chimpanzees evolved into humans?" How do you respond?
2. In the previous section, we considered Hockett's view that duality of patterning is the key distinguishing characteristic of human language. In this section, we considered Chomsky's view that centrality of syntax is the key feature. Consider carefully what these two concepts mean. Are they fundamentally different? Are they the same thing?
3. Chomsky argues that the essential thought process necessary for human language is an understanding of recursion. But since it is characteristic of human thought, not language per se, we should see recursion occurring elsewhere in human behavior. Can you think of some examples?
4. As you go through this course, try to become more aware of your language use. In particular, pay attention to when you are using

language to communicate information and when you are using it to communicate feelings.

Google It! Pidgins

There is plenty of information (as well as misinformation) about human origins on the web. If you are interested in learning more about **human origins**, google it! Also, if you're mathematically inclined, you can google **recursion**. You'll find it has all sorts of uses in computer science, and it crops up repeatedly in nature. You can also google **pidgin** to see some specific examples. See if you can understand them. (But be careful, some so-called pidgins, such as Hawaiian Pidgin and Tok Pisin, are actually creoles. Still, can you make any sense out of them?)

Section 1.4: Living Fossils

- Pidgins are simplified languages, but they are very useful for communication when no common language is available. They also suggest that an intermediate step between animal communication systems and full-fledged human languages is evolutionarily viable; the one-generation transition from pidgin to creole lends some support to discontinuity theories.
- All pidgins have certain characteristics in common: (1) they have simple phonology, (2) they generally lack morphology, (3) they have limited vocabularies, (4) they have little or no syntax, and (5) they are effortful to produce and comprehend.
- Early attempts to teach speech to primates failed because they lack the vocal tract structures required to produce the full range of speech sounds.
- Later attempts to teach signed or visual-symbol language to primates have shown that they can acquire a small vocabulary and can actively produce two- and three-word utterances, but the complexities of full language seem beyond their grasp.
- Language development suggests a trajectory for language evolution; the shift from short utterances to full sentences shows

that the change is continuous, consistent with continuity theories, but rapid, consistent with discontinuity theories.

- Brain damage can lead to a loss of language abilities; these patients often are only capable of pidgin-like utterances that are short, ungrammatical, and effortful to produce.

Continuity theories of language evolution are consistent with Darwin's (1859) theory of natural selection, which has been very successful in explaining the origin of species. An important line of evidence for evolutionary biologists is the fossil record, which has preserved the forms of plants and animals that went extinct long ago. On the other hand, the debate about language evolution based on fossil evidence from early humans, such as *Homo erectus* and the Neanderthals, has generated more heat than light. Some researchers maintain the fossil record suggests that spoken language was not anatomically possible before modern humans (Holden, 1999; Lieberman, Crelin, & Klatt, 1972; Lieberman & McCarthy, 2007). However, other researchers do find evidence in the fossil record for language ability in pre-modern humans (Boë et al., 2004; Hayden, 2012; Krause et al.,2007; Wolpoff et al., 2004). Little of the fossil record was known at the time Darwin developed his theory of natural selection. Instead, he looked for clues about evolutionary history in existing forms. In this section, we will consider some of the "living fossils" that provide a glimpse into how language could have evolved.

Half an Eye

Those who oppose evolution on religious grounds often challenge the theory with the question: "What good is half an eye?" Darwin himself recognized this as a potential problem for his theory, which maintains that every feature of a species evolved slowly across many generations and that, in every step in the process, these halfway features were beneficial to those who bore them. The half-an-eye question is interesting not in its logic but rather in that fact that it has been smugly repeated so many times in spite of the unassailable evidence that the eye did in fact evolve from a patch of light-sensitive skin—and not just once but dozens of times (Lamb, Collin, & Pugh, 2007).

At bottom, the half-an-eye question is not really about the evolution of visual systems; instead, it's a question about the status of humans in comparison with all the other animals that occupy this planet. We want to believe we are special, different. We use the words "human" and "animal" as if they referred to two separate categories. Yet at a biological level there is nothing to distinguish us from other animals. We share at least 98% of our genes with our cousins, the chimpanzees, and we're not much farther genetically from gorillas and orangutans either (Bradley, 2008).

Scientists who understand this still use the human/animal distinction. But when they say human, they mean an animal of the genus *Homo*, and when they say animal they mean any animal outside the genus *Homo*. This usage is less precise though more elegant than the politically correct but linguistically clunky "human animal" and "nonhuman animal." In this book, we'll go with elegance over precision, but now you know what I mean by "human" and "animal."

Still, all of us have lurking inside us the implicit bias that we humans are qualitatively different from (and hence superior to) all other animals. It's this implicit bias that's at the heart of the continuity debate, which centers on the question of whether human language could have evolved through a series of gradual steps, or whether there's something unique about human language that could have only occurred through a sudden and considerable reorganization of the human brain.

In part, this debate also hinges on how you define language. If you think of language as a communication system for transmitting thoughts from one person to another, you will be pushed toward the discontinuity side of the debate. This is because any meaningful definition of "thought" would have to include some concept of recursion or combinatory power. On the other hand, if you think of language as a communication system for building and maintaining social relationships, then it will seem obvious how human language could have evolved gradually out of animal communication. Viewing language as an all-or-nothing phenomenon, the discontinuity theorist asks, "What good is half a language?" But the continuity theorist merely retorts, "Far better than no language at all." As any traveler to a foreign country knows, even a few words of the local language, combined with a friendly expression and the appropriate gestures, can get you pretty far.

If implicit human arrogance drives the discontinuity theories of language evolution, a different implicit bias haunts the continuity side of the debate, and that is **anthropomorphism**. In other words, we have *the tendency to assign human-like qualities to animals, natural phenomena, and even abstract* *concepts*. Anyone who has ever spent some time with nonhuman primates knows it's hard not to think, "They're so much like us!" But we need to ask ourselves to what extent they really are just like us and to what extent we're merely projecting our own thoughts and intentions on them, just as we beg our car to start on a cold winter's morning, as if it had a will of its own.

In weighing the evidence on both sides of the debate, we need to steer between arrogance and anthropomorphism, to weigh the facts with all the objectivity we can muster. Regardless of which side of the debate we favor, there is one fact that is inescapable—in the natural realm, continuity rules, and hopeful monsters are rare (Theißen, 2006).

Me Tarzan, You Jane

Whenever people who don't share a common language meet, they'll find a way to communicate. We've already seen this when British traders landed in China in the eighteenth century, and it's a process that has repeated itself countless times throughout history. Hawaiian pidgin is one such example. In the nineteenth century, English-speaking plantation owners imported workers from Japan, Korea, the Philippines, and other countries. With no common language among all these different groups, a pidgin emerged based on the dominant language of the plantation owners. Thus, Hawaiian pidgin consisted mainly of English words with a smattering of items from other languages (McWhorter, 1999). Likewise, a number of pidgins arose in the eighteenth century in the West Indies and southern United States due to the slave trade.

Regardless of where they have arisen, all pidgins bear certain characteristics in common (Holm, 2000). First, pidgins have simple phonology. Consonant clusters are reduced or broken apart, only common vowel sounds are used, and tones are avoided altogether. Difficult sounds, such as the *th* sound in *them* and *there*, are replaced with sounds that are easier to produce, such as *dem* and *dere*. Oftentimes words are reduced from their original form, as in the case of the word *pidgin*, a reduced form of the word *business*. This simplification of phonology makes the words easy to pronounce and to distinguish from one another.

Second, pidgins generally lack morphology. In English we distinguish singular from plural nouns (*hand* and *hands*, *foot* and *feet*) and present from past verbs (*chase* and *chased*, *run* and *ran*). We also distinguish subject from object pronouns (*I* and *me*, *they* and *them*). But pidgins do not generally make such distinctions, using the same word form in all cases, such as *one man*, *two man* or *go today, go yesterday*).

Third, pidgins have quite limited vocabularies, usually just a few hundred words. Mostly, these are **content words**, such as concrete nouns, action verbs, and common adjectives, which are *words that carry the bulk of meaning in language*. There are few, if any, **function words**, such as *the* and *a*, *is* and *of*, which are *words that express grammatical relationships but carry little meaning*.

Fourth, pidgins have little or no syntax. Words can be combined to form simple sequences, but word order is generally free and probably based, at least in part, on the syntax of the speaker's native language. Pidgin speakers rely heavily on context to convey grammatical functions, and this context is generally sufficient as long as the sentences are short and the conversation is about everyday events. But the lack of word-order rules as well as function words precludes complex sentences.

Fifth, pidgins require effort to produce and to comprehend. It's important to keep in mind that nobody speaks a pidgin as a native language. If you've ever studied a foreign language, you know how challenging it is to come up with both the right vocabulary and the right grammar when speaking. The simplified structure of pidgins reduces the cognitive load on both the speaker and the listener, who can each focus on meaning without having to attend to proper form. It also makes pidgins much easier to learn than full-fledged languages.

The existence of pidgins demonstrates that humans can make use of communication systems that are more complex than animal calls or gestures but still much less complex than full human languages. In other words, pidgins provide an answer to the half-a-language question. In Section 1.3 we saw how linguist Derek Bickerton (1990, 2009) proposed that the full language capacity of modern humans evolved not out of the primate vocalizations but rather out of something that he called protolanguage, the pidgin-like communication system supposedly used by early humans.

Psychologists Steven Pinker and Paul Bloom also see pidgins as support for the continuity hypothesis. They point out that pidgin-like structures occur not only in the realm of intercultural communication but also in more mundane contexts such as the speech of toddlers and of people suffering from **aphasia**, which is *a* *language deficit due to brain damage* (Pinker & Bloom, 1990). Furthermore, attempts to teach some form of human language to non-human animals has shown that several species can learn simple pidgins, even though full language seems beyond their grasp (Bickerton, 2009). Thus, we can view pidgins as a sort of living fossil that can provide insight into what intermediate forms of language in early humans might have looked like.

Planet of the Apes

The great apes—chimpanzees, bonobos, gorillas, and orangutans—are our closest relatives, sharing up to 98% of their DNA with humans (Bradley, 2008). Thus, it's only logical to look first among these primate species for signs of latent linguistic ability.

The first known attempt to teach language to a nonhuman primate occurred in the 1930s (Kellogg & Kellogg, 1933). Psychologists Winthrop and Luella Kellogg brought the infant chimpanzee Gua into their home, raising her along with their own infant Donald as if they were brother and sister. At that time, the social sciences were dominated by **behaviorism**, *a school of psychology that emphasized the role of learning in shaping behavior*. So the Kelloggs' research question was whether a chimpanzee raised as a human would learn to behave like a human. The Kelloggs tested Gua and Donald each month on a number of cognitive tasks. The boy generally outperformed the chimp, even though Gua did learn a number of typically human behaviors. But the key difference was in language. By eighteen months, Donald was already producing words, but Gua, at a similar age, was not. The Kelloggs decided to end the experiment after nine months because Donald was imitating Gua's vocalizations.

Figure 1.9 Photo of a Bonobo

The bonobo is one of the most closely related species to humans, along with the chimpanzee and the gorilla. We share about 98% of our genes with these species. Members of these species have been able to learn simple sign languages to communicate with their human caregivers.

Source: © iStockphoto.com / seeingimages.

Two decades later, another husband and wife team tried to teach language to a chimpanzee (Hayes, 1951; Hayes & Hayes, 1952, 1953; Hayes & Nissen, 1971). Keith and Cathy Hayes raised the infant chimpanzee Viki as if she were a human baby. The Hayes's even gave Viki speech therapy, but at the end of three years, she could only produce four words, "mama," "papa," "cup," and "up." Considering that the average human three-year-old has a vocabulary numbering in the thousands of words, Viki's meager performance seemed to indicate that chimpanzees were incapable of learning language. However, it is now known that Viki's limitations were at least as much physical as they were cognitive. The **vocal tract** is *the system of air passages, including the throat, mouth and nose, where speech is produced*. But the shape of the vocal tract in other primates is somewhat different from that in humans, and this difference prevents them from producing the full range of human speech sounds (Lieberman, 2012). Nonhuman primates also appear to have less fine motor control over the tongue, jaw, and lips, which is also essential for producing speech.

Primates do, however, have a degree of manual dexterity similar to humans, and so the next attempt to teach language to a chimpanzee made use of signed instead of spoken language. In 1967, Allen and Beatrix Gardner adopted the infant chimpanzee Washoe and raised her as a human infant, the only difference being that they used American Sign Language (ASL) instead of spoken English (Gardner & Gardner, 1969, 1975, 1984, 1998; Gardner, Gardner, & Van Cantfort, 1989). Scientists are creatures of habit, just like the rest of us, and at first the Gardners tried teaching Washoe by means of **operant conditioning**, which is *a method for reinforcing desired behavior through the use of systematic rewards and punishments*. However, they soon discovered that Washoe was able to pick up new signs by observing others use them, just as human children do, and the Gardners switched to natural conversation and interaction with Washoe instead. Washoe acquired a vocabulary of several hundred words, and she was able to combine signs to express novel concepts. For example, on seeing a swan, Washoe made the signs for "water" and "bird."

Shortly thereafter, Penny Patterson reported similar results with the female lowland gorilla Koko (Bonvillian & Patterson, 1993; Patterson, 1978). After thirty months of training, Koko had an active vocabulary of around a hundred words. According to Patterson, Koko not only used these words spontaneously, she also could combine signs to express novel meanings. For example, she is reported to have made the signs for "finger" and "bracelet" to refer to a ring.

Another workaround to the lack of vocal control in apes has been the use of **lexigrams**, which are *visual symbols that stand for words*. These lexigrams can be made out of plastic tokens, printed on a laminated sheet, or even placed on a keyboard and displayed on a computer monitor. A number of ape-language projects have used this approach. Early projects using lexigrams investigated the question of whether primates could learn elements of syntax. To this end, a simple grammar for ordering lexigrams was designed. The first success with this approach involved a chimpanzee named Sarah, who was able to respond appropriately to "if-then" and "more-less" statements (Premack & Premack, 1984). Another team of researchers also reported success with a chimpanzee named Lana, who, they claimed, could also construct novel, grammatically correct utterances with the lexigrams (Rumbaugh, 1977).

To date, the most successful attempt to teach language to an ape has involved the bonobo Kanzi (Gillespie-Lynch et al., 2011; Lyn et al., 2011; Savage-Rumbaugh, Shanker & Taylor, 1998). Bonobos are a separate species from common chimpanzees. They're also less aggressive and therefore easier to train. Originally, Savage-Rumbaugh and her colleagues were attempting to teach Kanzi's mother to communicate with lexigrams arranged on a laminated sheet, but she was often distracted by baby Kanzi and was disengaged by the monotonous operant-conditioning approach the researchers were using. When Kanzi spontaneously began using the lexigrams to communicate with the researchers, they turned their efforts to him instead. According to Savage-Rumbaugh and her colleagues, Kanzi also picked up some sign language by watching tapes of Koko the signing gorilla. More important, they also claim that Kanzi can understand spoken English, even though he can't speak. In a controlled listening comprehension task, nine-year-old Kanzi performed at 72% correct compared with the 66% performance of a two-and-a-half-year-old human child.

In short, these studies show that, under the right conditions, primates can acquire small vocabularies, and they can combine the words they know to form short, novel utterances. However, this is no easy feat for these primates to accomplish, and they take many years of training and interaction with humans to achieve a similar level of communication to that of a human toddler. In other words, they learn pidgin but not full-fledged human language.

The ape-language research program has ignited a heated debate in the literature, reminding us that scientists are primates too. On the one hand, researchers who view syntax as the key defining feature of language argue that so-called language-trained primates are not really using language. For example, Terrace and his colleagues carefully examined thousands of two- and three-sign utterances made by the language-trained chimpanzee Nim Chimsky and found little evidence of grammatical structure in novel utterances (Terrace et al., 1979). Rather, most of Nim's utterances either were repetitions of what his teacher had just signed or were memorized sequences, and they found little evidence of syntactic structure in novel utterances.

On the other hand, researchers such as Savage-Rumbaugh push the social interaction aspect of language (Givón & Rumbaugh, 2009). Furthermore, they emphasize the fact that human language development moves from nongrammatical pidgin-like utterances to grammatical sentences. As Trachsel (2010) points out, this is also the likely evolutionary trajectory of human language, as it's consistent with Darwinian evolution. Savage-Rumbaugh and her colleagues concede that language-trained apes don't exhibit complex syntax in their utterances, but they also insist that their utterances are nonetheless communicative, a point Terrace and colleagues also concede.

Baby Talk

Babies aren't born talking. Rather, they go through a very predictable sequence of language development. They spend most of their first year vocalizing, at first in ways that don't sound very language-like, but gradually their vocalizations take on aspects of the language spoken around them. As infants babble, they practice making the speech sounds they'll use later when they speak.

Around one year of age, they utter their first words, and for the next half year or so, their vocabulary is limited to a few dozen words (Ganger & Brent, 2004). During this time period, the child produces holophrases (Braine, 1974; Dore, 1975). Thus, "Kitty!" means something like, "Look, there's a kitty!" Likewise, "Milk!" means something like, "Give me the cup of milk." And "Ball!" means something like "Here's the ball!" These holophrases are much like the animal calls we learned about in Section 1.1, in that they refer to an event taking place at the current place and time, and they cannot be used to speak about events at other times or places.

At first, word learning appears slow and effortful, but halfway through the second year, there is a shift in the way the child approaches new words. This period is known as the **vocabulary spurt**, and it is *a time in which the child begins learning new words at a rapid pace, usually starting around eighteen months of age* (Goldfield & Reznick, 1990; Nazzi & Bertoncini, 2003). Around the same time, children begin making two-word combinations (McEachern & Haynes, 2004; Starr, 1975). These two-word utterances have all the hallmarks of pidgin sentences, in that they are strung together based on semantic relationships rather than syntactic structure. Over the next few years, vocabulary and syntax develop hand in hand, so that by age five or so the child has become a competent speaker of the language.

To the extent that the development of the individual mimics the evolution of the species, a child's first language acquisition may shed light on the stages of language evolution from pre-humans to the present day. Infants emit cries that elicit nurturing behavior in their mothers; rat pups behave similarly, producing ultrasonic vocalizations when they need their mother's attention (Stern, 1997). Around their first birthday, children begin producing one-word holophrases, similar to those of animal communication systems we've already looked at. By their second birthday, toddlers are producing pidgin-like utterances of two or three words. They also go through a vocabulary and syntax spurt as they transition to full language. Although this transition is continuous, it's also rapid, and so it's consistent with either continuity or discontinuity theories. In short, language development in individual humans suggests a plausible trajectory for language evolution in the human species.

At a Loss for Words

If you put your finger just in front of, and a little above, your left ear, you'll be pointing at a part of your brain known as Broca's area. In 1861, French surgeon Paul Broca reported the case of a patient with damage to this area (Lorch, 2011). Although the patient appeared to still be able to understand spoken language, he'd lost the ability to speak (except for the nonsense syllable *tan* and a few choice obscenities). **Broca's aphasia**, then, is*a type of aphasia characterized by disjointed or ungrammatical speech* (Sahraoui & Nespoulous, 2012). Patients with Broca's aphasia appear to be exerting great effort just to find words in memory and produce them, and their speech largely consists of content words with few function words and little regard for syntax (Rochon et al., 2000). In other words, the speech of Broca's aphasics has many of the properties of a pidgin.

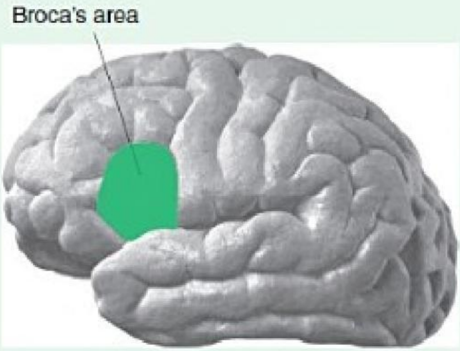
Broca's area is right next to the motor cortex area of the brain that controls the movement of the speech articulators, such as the jaw, lips, and tongue. This arrangement seems reasonable, given that it's *an area of the brain that plays a role in speech production.* It's possible that Broca's area evolved from brain areas that were responsible for producing vocalizations in our pre-human ancestors; in fact, a similar area in primate brains is activated when calls are produced (Gil-da-Costa et al., 2006).

However, Broca's aphasia doesn't just disrupt spoken language; it similarly affects those who use signed language (Horwitz et al., 2003). This suggests that Broca's area isn't responsible specifically for speech production but rather more generally for language production, whether spoken or signed. On the one hand, this is an unexpected finding because native signers generally don't move their speech articulators when they sign (though many people learning

ASL do vocalize the English equivalent while signing). On the other hand, signed languages display the same hierarchical structure and complexity of syntax as spoken languages, so maybe there's more to Broca's area than just producing speech.

Figure 1.10 Broca's Area

Damage to Broca's area leads to difficulty in producing speech, although the patient can still understand speech.



Copyright: Sage.

Furthermore, Broca's area isn't only involved in language production. Rather, activation in this area also underlies tool use, both in humans and in primates (Hopkins, 2010). Although the connection between language and tool use isn't immediately obvious, there's a relationship at a more abstract level. Both involve the precise sequences of fine motor movements. Specifically, we're referring to the jaw, tongue, and lips in the case of speech and the arms, hands, and fingers in the case of tool use. Language and tool use are also both activities that are organized in hierarchical structures (Greenfield, 1991). This suggests a connection between developing tool use in the primate line and the use of meaningful vocalizations that later developed into language (Higuchi et al., 2009).

Whatever the original purpose of Broca's area was, it's clear that we humans depend on it for fluently sequencing words into sentences. When this area is damaged, we can no longer arrange words according to the rules of grammar.

That is to say, we can no longer build hierarchical structures for organizing our words, but instead we produce words like beads on a string, roughly related in meaning but not held in place by an overarching sentence structure. It's also commonly observed that Broca's aphasics will augment their communicative attempts with pointing and gestures and even drawing pictures (Cicone, 1979). People communicating by pidgin often resort to gestures and pictures as well to get their point across (Wilkinson, Beeke, & Maxim, 2010).

In Sum

The "living fossils" of language suggest a continuous evolution from holophrases to pidgins to full language. However, the single-generation transition from pidgin to creole and the rapid development of vocabulary and syntax in children can be interpreted as evidence for discontinuity theories. Primate language research also shows that chimpanzees and gorillas have some of the cognitive abilities necessary for language, but they require extensive human interaction to develop.

Review Questions

1. Describe the five common characteristics of pidgins. How do these features make pidgins simplified compared with full languages?
2. What methods have been used to teach language to primates? What are the results of primate language research?
3. Briefly describe the progression of language acquisition in children. What does this process suggest about the evolution of language?
4. What are the symptoms of Broca's aphasia? What does this suggest about the function of Broca's area? What is the role of Broca's area in primates?

Thought Questions

1. How is the half-an-eye question relevant to the debate on the

evolution of language?

2. There are two major approaches to teaching language to primates. One involves creating a natural environment similar to that in which human children learn language, and the other involves rigorous behavioral methods such as operant conditioning. What are the advantages and disadvantages of each approach?
3. What evidence suggests that Broca's area may be involved in more than just speech production?
4. Greenfield (1991) proposes that language and tool use are related because both are organized in hierarchical structures. This suggests that there is also a duality of patterning in tool use, namely a set of meaningless actions that can be combined according to rules into meaningful sequences. Try coming up with a grammar for a simple tool use such as brushing your teeth; be very specific about all the component actions and the restrictions on how these can be sequenced. If you find this easy, try developing a grammar for driving a car.

Google It! Washoe, Koko, and Kanzi

You can find more information, including pictures and videos, about some of the language-trained primates you read about in this section, including **Washoe**, **Koko**, and **Kanzi**. Also, Pepperberg (2002) has reported on a language-trained African grey parrot named **Alex.** You can watch videos **of Alex the parrot** interacting with Pepperberg on YouTube. Are you convinced Alex understands what he's saying? You can also find videos on YouTube of patients who've suffered from **Broca's aphasia.** Imagine what it must be like to be one of these patients. How do they try to compensate for their language loss?

Conclusion

Many animal species use communication systems to attract mates, warn others about threats, and maintain group cohesion. Humans communicate for these reasons as well, but human languages are structurally far more complex, allowing humans a much wider range of expression. It’s unclear how human language evolved, but a number of theories touch on some aspects of this process. Some insights into the origin of human language can be gleaned from “living fossils”: pidgins and creoles, attempts to teach human language to chimps, human infant language development, and language loss due to brain damage.

Humans express emotions in ways similar to animal communication systems, using vocalizations, gestures, posture, and facial expressions. However, human language has a much wider range of expression by combining elements to create novel utterances. Language also lets us to escape the here and now to discuss events that took place at other times and places. These unique features are due to the hierarchical structure of language. Speech sounds combine to form words, words combine to form sentences, and sentences combine to form larger units such as conversation.

The question of whether human language evolved gradually or rapidly is known as the continuity debate. Discontinuity theories propose that human language arose rapidly, perhaps as the result of a single genetic mutation, and they emphasize the disparity between present-day animal communication and human language. Continuity theories assume a more gradual evolution of human language from animal communication, and they’re more in line with standard evolutionary theory. However, they have difficulty explaining the lack of intermediate stages between animal communication and human language. Although language is the unique feature of humans that makes us different from all other animal species, we still need to keep in mind our humble origins and the fact that we left the wild not that long ago.

Cross-Cultural Perspective: Hawaiian Pidgin

Whenever groups of people who don’t speak the same language find themselves living and working together, they develop a pidgin to communicate with each other. A pidgin is a simple language with a small vocabulary and a simple grammar, but it’s good enough for basic interactions. As global trade developed in the eighteenth and nineteenth centuries, pidgins cropped up in many locales around the world.

One place where a pidgin emerged was Hawaii. In the nineteenth century, English-speaking plantation owners brought in workers from East and Southeast Asia. Words were borrowed from English, Hawaiian, Japanese, and other languages (Sakoda & Siegel, 2003). The children of these workers then developed their parents' speech into a language they called "Pidgin." Despite its name, Hawaiian Pidgin is in fact a creole, and it's still widely spoken across the Hawaiian islands today.

Many Hawaiians grow up speaking Pidgin, which they see as an important part of their ethnic identity. Billboards and TV advertisements in Hawaii often incorporate Pidgin expressions to appeal to the local population. Hawaiian Pidgin even has a written form based loosely on English spelling conventions. See if you can recognize the following well-known psalm verses, as presented in the Hawaiian Pidgin Bible (*Da Hawai'i Pidgin Bible*, 2000).

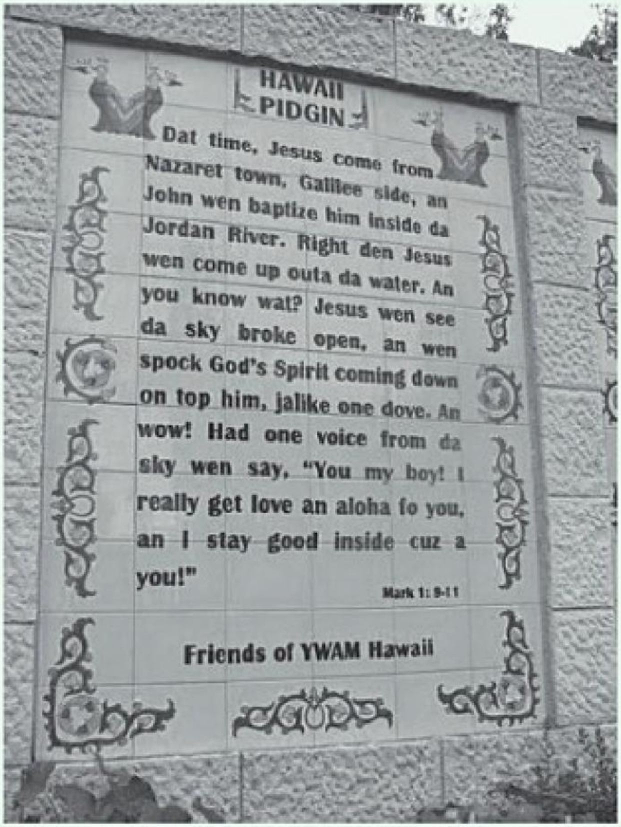
> Da Boss Above, he take care me, jalike da sheep farma take care his sheeps. He goin give me everyting I need. He let me lie down wea da sweet an soft grass stay. He lead me by da water wea I can rest. He give me new kine life. He lead me in da road dat stay right, cuz I his guy. (Psalm 23: 1–3)

It might make more sense to you if you read it out loud. (The only tricky word here is *wea*, which is pronounced *way-uh* and means "where.")

If you'd like to hear what Pidgin sounds like, you can listen to Kathy Collins's (2009) open letter congratulating Barack Obama as the first president from Hawaii. Google *Maui Magazine* and then search for "Dear Prezadent Obama." Both the text and the audio are available, so you can read along as you listen.

Figure 1.11 Inscription in Hawaiian Pidgin

This inscription in Hawaiian Pidgin is located at the Yardenit Baptismal Site on the Jordan River in Israel. Although its speakers call their language Pidgin, it's really a creole that developed from an earlier pidgin.



Source: Prokurator11/Wikimedia Commons/Public Domain.

Because English provides most of its vocabulary, many people criticize Pidgin as nothing more than broken English. While Pidgin doesn't follow the forms of Standard American English, it nevertheless has a structure of its own. It's important to keep in mind that there's no such thing as a "pure" form of a language. Instead, languages are constantly changing to fit the needs of the speech communities that use them. Pidgin is a living language and an important component of the Hawaiian identity for many thousands of people.

Key Terms

Alarm call
Anthropomorphism
Aphasia
Arbitrary symbol
Behaviorism
Broca's aphasia
Broca's area
Centrality of syntax
Chunking
Communication
Conspecific
Content words
Continuity debate
Continuity theories
Creole
Discontinuity theories
Discourse
Displacement
Dominance hierarchy
Duality of patterning
Ethologist
FOXP2
Function words
Holophrase
Hopeful monster hypothesis
Iconic symbol
KE family
Lexigrams

Morphemes
Morphology
Mother tongue hypothesis
Motherese
Operant conditioning
Phonemes
Phonology
Pidgin
Primacy of speech
Protolanguage
Recursion
Singing Neanderthal hypothesis
Social grooming
Social grooming hypothesis
Speciation
Specific language impairment
Syntax
Vocabulary spurt
Vocal tract
Working memory

Chapter 2 The Science of Language

Something had gone terribly wrong. They'd been running experiments like these for months now, always with the same result. When they'd started this experiment—really no more than a simple tweak on the basic design—they were quite confident they knew what the data would look like.

They were using a new technique to monitor brain activity, and the equipment was state of the art. But the experiments were also tricky to perform. First you had to carefully glue dozens of electrodes in just the right locations on the scalp of a willing and patient research participant. Then you presented the stimuli—usually a series of words or pictures—to the participant while an electroencephalograph recorded his or her brain activity. After that, the data were fed into a powerful computer, which extracted isolated waveforms known as event-related potentials, or ERPs. There was plenty that could go wrong with an ERP experiment, but that would just lead to garbage output, not the clean data they were looking at.

The researchers had been studying an ERP component known as the P300. The brain produces a P300 every time it encounters an unexpected stimulus, such as an item that's out of order in a series. They'd found that they could also get a P300 to linguistic stimuli, such as when the last word of a sentence is presented in larger font, as in:

SHE PUT ON HER HIGH HEELED SHOES.

This time, they'd changed the meaning instead of the size of the final word, as in:

HE SPREAD THE WARM BREAD WITH SOCKS.

They were expecting a P300 this time as well, but that's not what they got. Instead, the waveform went in the opposite direction. It was totally unexpected.

This is the story of how young Marta Kutas, working as a postdoctoral student in the lab of noted neuroscientist Steven Hillyard, discovered the N400, one of the most important and influential findings in the history of psycholinguistics (van Petten, Federmeier, & Holcomb, 2010). Their paper reporting on the N400 in the prestigious journal *Science* (Kutas & Hillyard, 1980) has been cited more than a thousand times, and the N400 is now a standard tool for studying how the brain processes language.

In this chapter, you'll learn about how psychologists use the scientific method to study the mental processes involved in language perception and production. You'll read about ERP research, the P300, and the N400 as well as many other many other tricks of the psycholinguistics trade. Also you'll see that sometimes the greatest discoveries are made when things go terribly wrong—and that's the true wonder of science!

Section 2.1: Scientific Method

- A theory provides a conceptual framework for explaining a set of observations; it should make predictions about future observations that can be tested in experiments.
- A prediction that is derived from a theory is known as a hypothesis; the researcher then collects data to test the hypothesis.
- Hypotheses derived from a theory must have the possibility of being disconfirmed by data; this is known as the falsifiability criterion.
- Science has three successive goals: (1) naturalistic observations are used to describe phenomena, (2) correlational methods find patterns in the data that can be used to make predictions, and (3) experimental methods seek to explain phenomena by testing hypotheses derived from theories.

- Theories are often expressed as models, which attempt to explain underlying mechanisms, typically in the form of a graph, a set of mathematical equations, or a computer simulation.
- Constructs provide scientists with useful ways of thinking about the world, and operational definitions then define those constructs in terms of how they are to be measured; operational definitions must be both valid and reliable.

Two of the most important concepts in science are theory and hypothesis. But the way these terms are used in the common language is quite a bit different from the way scientists use them, which often leads to misunderstandings about the enterprise of science. In everyday language, the words *theory* and *hypothesis* are used more or less interchangeably to refer to a hunch or conjecture. A detective will gather clues and formulate a hypothesis about the identity of the murderer, and your highly opinionated uncle may have a theory about the global recession that involves a conspiracy between the Freemasons and the Michigan Militia. “Well, it’s just a theory,” he rebuts when you point out the inconsistencies in his argument.

Just a Theory

The “just a theory” comment aptly sums up the common view of what a theory is. This public misconception about what scientists mean by theory provides ammunition for those who wish to attack science on religious grounds, as for example when the Cobb County (Georgia) school district placed stickers on biology textbooks warning students that evolution is a theory, not a fact (Holden, 2006). Evolution is a theory, but not in the Cobb County sense.

Scientists use the term **theory** to refer to *a conceptual framework that explains a set of observations in such a way that it also makes predictions about future observations.* For example, in the 1950s noted psychologist George Miller thought he had detected a pattern in the data from a number of experiments testing people’s ability to discriminate sensory inputs, attend to objects, and recall information. In his famous “Magic Number Seven” paper, Miller (1956) proposed that short-term memory capacity is limited to about seven meaningful chunks of information. This theory explains results from the **digit span task**, which is *a procedure that assesses short-term memory capacity by having research participants repeat lists of digits*. But the theory also predicts you’ll get similar results if you use lists of words instead of lists of digits because words, like digits, are meaningful units, or chunks.

Theories can only be tested if they make predictions. *A prediction about future observations that is derived from a theory* is called a **hypothesis**. It's the hypotheses we formulate that allow us to test the theory. In other words, a hypothesis states what we expect to observe in a particular situation if the theory is correct. We then make that observation, and if the observation matches our expectation, we say that we have found support for the theory. In fact, further observations do support Miller's theory of short-term memory capacity, since you get similar results to the digit span task if you use lists of common words instead (Baddeley, Thomson, & Buchanan, 1975).

You Can't Prove It

You can never prove a theory true, but you can prove it false. When our observations of the real world don't match the hypotheses we derive from a theory, intellectual honesty dictates we must conclude that the theory is wrong. Thus, the true test of a theory isn't whether it leads to hypotheses that can be confirmed by observation. Rather, we follow *the principle that a theory must make predictions that have the potential to be disconfirmed by data*. This principle is known as the **falsifiability criterion**, and its importance in the scientific enterprise was first emphasized by philosopher Karl Popper (1959). Thus, a good theory will be very specific about expected outcomes (Stanovich, 2007), and the scientist proposing it must be willing to take the risk of being wrong (Ben-Ari, 2005).

Miller's (1956) theory of short-term memory capacity meets the falsifiability criterion. The theory predicts that people can recall about seven chunks of information—whether words or digits—immediately after hearing them. Immediate recall tasks of digits or common words lend support to this theory. In a strong version of this theory, you should be able to hold onto about seven chunks of information, regardless of their size. However, Alan Baddeley suspected that size did matter, conceptualizing short-term memory instead as a buffer limited by length of time. In a classic set of experiments, Baddeley et al. (1975) had research participants repeat lists of short words and lists of long words. On the short word task, participants were able to repeat about seven items on average. But on the long word task, their performance was much worse. Thus, the data support Baddeley's model and disconfirm Miller's.

Baddeley's model is also superior because it accounts for the data that originally supported Miller's model. Baddeley proposed a mechanism called the **phonological loop**, which is *a short-term memory buffer that can hold about two seconds of spoken language*. The average speaking rate is about three or four syllables per second, and most of the digit names consist of a single syllable (zero and seven are the exceptions). Hence, you can say about seven digits in two seconds, and Baddeley proposed that you say them to yourself as you hold them in memory until it's time to repeat them. If there are more than seven or so digits, the list takes longer than two seconds to say, and you overwhelm the phonological loop. Likewise, if most of the words in the list are multisyllabic, you will reach the end of the loop before the end of the list. Baddeley also referred to short-term memory as working memory instead to emphasize its active nature.

From Observation to Explanation

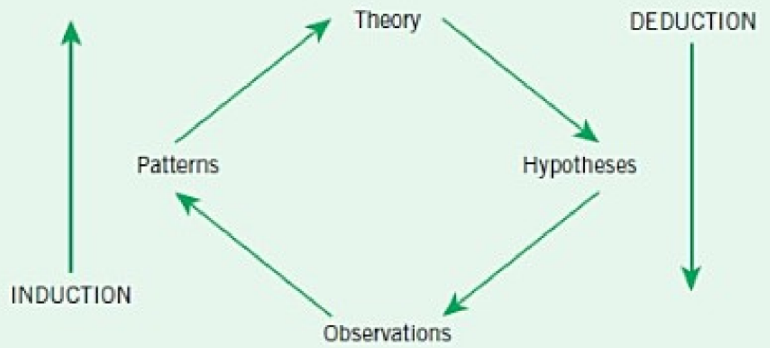
The scientific method is a cyclical process, but it always has its starting point in the real world. Scientists observe the real world, making observations and collecting facts, and then they formulate a theory to account for the data they've collected so far. *The logical process of going from specific examples to general statements* is known as **induction**. But recall that a theory must also make predictions about future observations, and *the logical process of going from general statements to specific examples* is called **deduction**. Scientists then go back to the real world to see if these predictions are accurate. A hypothesis that is confirmed by the data (observations) lends support to a theory, but still the theory needs to be tested multiple times to strengthen our confidence in it, so we do more hypothesis testing. If the hypothesis fails to support the theory, we revise the theory and generate new hypotheses. Either way, the cycle starts again.

It may surprise you to read that scientists go to the "real world" to collect data, since many scientists work in laboratories. To most people, a laboratory is the farthest thing from the real world. But for a scientist, the laboratory *is* the real world, stripped down to the bare bones to rid it of all its "blooming, buzzing confusion" (James, 1890/1981, p. 462). Still, scientists can test the real-world validity of their theory by doing *a study conducted under natural circumstances outside of the laboratory*, and this is called a **field study**. The tests that Zuberbühler et al. (1999) performed on Diana monkey alarm calls that we discussed in Chapter 1 are an excellent example of this.

Until now, we’ve been talking about the scientific method as if it were a single, unified approach, but in fact science has a number of methods at its disposal, depending on the research question being asked and how much we already know about the phenomenon under study. At the beginning of a research program on a new topic, it’s generally best just to watch carefully and take detailed notes. *The process of observing and describing a phenomenon* is known as **naturalistic observation**. As an example of naturalistic observation, consider the study of speech errors. Although researchers have speculated for years about why people make slips of the tongue, linguist Victoria Fromkin (1971) decided to approach the phenomenon in a more systematic fashion. She began by simply recording in a notebook examples of speech errors that she heard. Eventually, she amassed a database of several thousand items.

Figure 2.1 The Research Cycle

Scientists make observations to detect patterns, from which they propose a theory. They then generate hypotheses, which are predictions about future observations. These new observations, called experiments, test the hypotheses and provide evidence for or against the theory. The process from patterns to theory involves induction, while the process from theory to hypotheses involves deduction.



This database, by itself, doesn’t tell us much about the nature of speech errors. However, by searching through this database, Fromkin found that speech errors followed predictable patterns. Now we know that even when we make mistakes in speaking we still follow rules! (You’ll learn more about these patterns in Chapter 4.) When the data we collect come in the form of numbers, we can use **correlation**, which is*a mathematical technique that searches for relationships among variables in a set of data*. For example, college GPA and

ACT scores are correlated, which means that admissions officers can roughly predict how well applicants will do in college based on their ACT scores.

Ultimately, scientists seek to understand the underlying factors that cause the phenomenon they're studying. Fromkin's initial work in collecting speech errors and detecting patterns in their production has led to a fruitful research program involving a number of language scientists. Researchers developed methods for inducing speech errors in the laboratory (Baars, Motley, & MacKay, 1975). This enabled scientists to use the **experimental method**, *a means for systematically testing hypotheses in controlled situations*, to investigate the factors leading to speech errors. For instance, Motley and Baars (1979) found that male college students were more likely to make speech errors of a sexual nature in the presence of a provocatively clad female researcher. Since explanation is the ultimate goal of science, the experimental method is considered the gold standard of science.

While a good theory needs to make specific predictions about future observations, a better theory also proposes an underlying mechanism to account for those observations (Ben-Ari, 2005). When scientists study complex phenomena (such as human psychology), they often build models to help them understand the processes behind the behavior they observe. A **model** is *a simplified version of the phenomenon under investigation, typically in the form of a graph or set of mathematical equations*. Because models are proposed mechanisms for how theories work, the two terms, *model* and *theory*, are often used interchangeably.

Oftentimes, models are implemented as computer programs, and the model is considered good if it mimics the behavior that's being studied. Humans are notoriously flawed at logic, and scientists can easily make unwarranted assumptions when working out models with pen and paper. But computers are, quite literally, logic machines, and so expressing the model in computer code forces the theorist think in a logical, step-by-step fashion. Thus, a good model lends plausibility to a theory, but only data from experiments can support or falsify a theory. We will learn about a number of models in the chapters that follow.

Constructs

Science is a process of systematic observation, and yet many of the topics we study as psychologists are abstract and not directly observable. Concepts such as memory, cognition, emotion—and even language—don't represent real objects in the real world. Rather, each of these is a **construct**, which is a *label given to a set of observations that seem to be related*. For example, there's no way to measure memory, because it's an abstract concept. Instead, we measure outward behaviors, such as digit span and list recall, and make inferences about something we call memory on the basis of those behaviors.

A construct provides scientists with a useful way of thinking about the world, but they don't worry about what the construct actually means. Rather, the construct is given an **operational definition**. That is, scientists make a *definition of a construct in terms of how the construct is measured*. Perhaps the most infamous example of an operational definition in psychology is by Edwin Boring, who defined intelligence as what is measured on an intelligence test (Boring, 1923). Although Boring's definition sounds circular, it's not. Instead of quibbling about the true nature of intelligence, Boring proposes we avoid that question altogether and focus instead on the data, in this case scores on IQ tests. Operational definitions let scientists dodge the philosophical "true nature of" type of questions and focus their energy instead on doing science.

Operational definitions are only as good at the measurements on which they are based. There are two criteria for evaluating an operational definition. The first criterion is **validity**, which refers to *the degree to which the measuring instrument actually measures what it is claimed to measure*. If I stand on my bathroom scale, I'll get a three-digit number, which I take to be my weight. Scales are specifically designed to measure weight, and so I believe my bathroom scale to be valid. My IQ is also a three-digit number, but I don't take the number on my bathroom scale to be a measure of my intelligence, since there's no evidence that weight is related to intelligence. (If it were, I'd be a genius!) The second criterion is **reliability**, which is *the degree to which the instrument gives consistent measurements for the same thing*. My bathroom scale is old, and depending on the temperature and humidity on a given day, my weight (as measured by the scale) can vary by ten pounds. I doubt my body weight really fluctuates by that much, so I consider my bathroom scale to have low reliability.

By testing and refining our theories, we gain a deeper understanding of the world, but the truth—as we understand it—is always tentative, not absolute. Scientists as individuals suffer the same frailties and vanities that all humans possess, yet science as a social enterprise is a self-correcting process. Thus, science is the most powerful tool we have for understanding the world, and ourselves.

In Sum

Science is a set of methods for systematically observing the world. These observations are guided by theories, which are tentative explanations for how things work. Hypotheses are expected observations based on the theory, and we can use them to test the theory by checking whether our hypotheses and observations match. We can never prove a theory correct, because there is always the possibility that new evidence will disconfirm the theory. Scientists use naturalistic observations to describe phenomena and search for patterns, and they use experimental methods to seek explanations for those phenomena. Models are attempts to explain the underlying processes that account for observed patterns. Models are often set up in the form of a computer simulation. Constructs are labels given to sets of observations that seem to be related. Operational definitions are used to define constructs in terms of how they are to be measured.

Review Questions

1. What is a theory? What is a hypothesis? What is a model?
2. Why can't you prove a theory true? How can you prove a theory false?
3. What are constructs? Why do they need to be operationally defined? What are validity and reliability?

Thought Questions

1. If someone tells you that evolution is just a theory and hasn't been proven as a fact, how would you respond?
2. Miller's "Magic Number Seven" is more accurately described as seven-plus or minus-two, in other words, the range between five and nine. Virtually anyone can repeat back a list of four digits or short words, and very few can reliably repeat back a list of ten or more. This limitation of short-term memory impacts the way we

format large numbers. Think about the important numbers in your life, such as telephone, Social Security, and credit card numbers. How many digits are they? How would you read these numbers to another person so that he or she could write them down?

Google It! Digit Span

There are a number of **digit span** and **word list recall** demonstrations available online. Some are offered by companies claiming they can help boost your cognitive performance. Try out the demos, but don't give them your credit card number!

Section 2.2: Experiment Design

- Hypotheses are derived from a theory by the logical process of deduction; an experiment is then designed to test the hypothesis.
- Experiments compare the performance of different groups; the experimental group is given a treatment to test the hypothesis, and the control group goes without the treatment in order to provide a baseline for comparison.
- An experiment can be viewed as a stimulus-response test. The independent variable is the type of stimulus, or treatment, each group is given; the dependent variable is a measure of the response each participant makes to the treatment.
- When each participant is assigned to only one condition, we say the experiment has a between-subjects design; when each participant is assigned to multiple conditions, we say the experiment has a within-subjects design.
- We express the hypothesis as a greater-than or less-than relationship between the groups, and if the data go in the predicted direction, we say they support the hypothesis.
- Because there are always alternative explanations for a set of results, no single experiment ever makes or breaks a theory.

Grandma loves to cook, and she's quite adventurous in the kitchen. She likes to "experiment" with recipes, changing ingredients and adding new items, just to see what will happen. The last time she baked her famous oatmeal cookies, she used dried cranberries instead of raisins and tossed in some butterscotch morsels just for the heck of it. "You never know how an experiment will turn out," Grandma says, and that's half the fun. Unlike Grandma, scientists never perform an experiment "just to see what will happen." In fact, they have a very clear expectation of what is going to happen in the experiment, and that expectation is called a hypothesis.

Elements of an Experiment

An **experiment** is *a tightly controlled situation that has been intentionally designed to test a hypothesis*. In its simplest form, an experiment involves a comparison between two groups. The hypothesis makes a prediction about a difference between these two groups in terms of their observable behavior. More complex experiments contain more groups, but still the hypothesis predicts how each group will perform compared with the other groups. We often refer to these groups as conditions because they each experience a different situation or treatment. The **experimental condition** refers to *the group that is given a treatment to test the hypothesis*, and the **control condition** refers to *the group that is treated differently from the experimental group to provide a baseline for comparison*. In the Baddeley et al. (1975) experiment, the presentation of the short-word list constituted the control condition. This is because its purpose was to demonstrate that the experimental technique would yield results similar to Miller's (1956) digit-span task. On the other hand, the presentation of the long-word list made up the experimental condition because it directly tested the hypothesis.

You can think of an experiment in terms of stimulus and response. Each group is given a different stimulus, or treatment, and then the response of each group is measured. *The various types of treatment given to the different groups in an experiment* are known collectively as the **independent variable**. In Baddeley et al.'s (1975) experiment, the independent variable was whether the participants were given a short-word list or a long-word list. *The measurement of the response each participant makes to the treatment in an experiment* is known as the **dependent variable**. The dependent variable that Buchanan and colleagues measured was the number of words recalled in each condition.

If an experiment compares the performance of different groups under different conditions, you would expect each of these groups to be composed of different participants, and this is often the case.*An experiment design that assigns each participant to only one condition* is called a **between-subjects design**. However, it's also possible, in some circumstances, to reuse participants through multiple conditions of the experiment. *An experiment design that assigns each participant to every condition* is said to be a **within-subjects design**.

Practical issues determine whether the experiment design should be between or within subjects. For example, Bransford and Johnson (1972) investigated the effect of context on story comprehension. All participants heard the same ambiguous story, but some saw a disambiguating picture first (the Context condition), while others listened to the story without the picture (the No Context condition). Obviously, once participants had taken part in the Context condition, they could no longer be in the No Context condition, because they were already familiar with the picture. And if they served in the No Context condition before the Context condition, they would already be familiar with the story. So in this case there really was no choice but to use a between-subjects design.

Figure 2.2 List Recall of Short Words and Long Words

Lists of short words were recalled better than lists of long words, providing support for the phonological loop hypothesis.

Source: Baddeley, Thomson, and Buchanan (1975).

However, research participants are a valuable commodity, and so it makes sense to recycle them whenever possible. That's what Baddeley et al. (1975) did. Since there's no reason to believe that repeating a list of short words will have any effect on your later ability to repeat a list of long words (or vice versa), it made sense to use a within-subjects design. In fact, the participants not only took part in both conditions, they also underwent multiple trials in each condition. A **trial** is *a single application of the treatment in an experiment*. In this case, each participant repeated eight short-word lists and eight long-word lists, for sixteen trials total. In short, running participants in multiple conditions and multiple trials can be a very efficient way to gather data, and psychologists take this approach whenever possible.

The Experimentation Process

The experimentation process is an extension of the inductive-deductive method. First, we deduce a hypothesis from the theory. Second, we design and conduct an experiment to test the hypothesis. Third, we do an analysis of the data. And fourth, we make an interpretation of the results. In our interpretation we must not only consider how the data provide support for the hypothesis, and hence for the theory, we need to also evaluate any shortcomings in the experiment as well as other possible interpretations of the results. This leads to new hypotheses that need to be tested, and the wheel spins another turn.

In the first step, we formulate our hypothesis in terms of an expected difference in the dependent variable between the groups. Bransford and Johnson (1972) expected that people who are given context for an ambiguous story will comprehend that story better than other people who are given no context. When the hypothesis is formulated in such a precise fashion, it not only dictates the basic design of the experiment but also states the expected outcome.

In the second step, we design a procedure that's expected to produce the hypothesized difference between the groups. Bransford and Johnson (1972) developed the following ambiguous story, which they read to the participants in the No Context condition:

> If the balloons popped, the sound wouldn't be able to carry since everything would be too far away from the correct floor. A closed window would also prevent the sound from carrying, since most buildings tend to be well insulated. Since the whole operation depends on a steady flow of electricity, a break in the middle of the wire would also cause problems. Of course, the fellow could shout, but the human voice is not loud enough to carry that far. An additional problem is that a string could break on the instrument. Then there could be no accompaniment to the message. It is clear that the best situation would involve less distance. Then there would be fewer potential problems. With face to face contact, the least number of things could go wrong.

The researchers then asked these participants to rate how difficult the passage was to understand, and they were tested on how many items from the story they could recall. Participants in the Context condition followed the same procedure, but they first got to see a disambiguating picture.

In the third step, we analyze the data to determine whether they provide support for the hypothesis, which is stated in terms of a "greater than" or "less than" relationship between the group means. Bransford and Johnson (1972) predicted that the comprehension rating for the Context group would be greater than the comprehension rating for the No Context. As you can imagine, the participants in the Context condition rated the story easier to comprehend and they recalled more details from the story than did the No Context. In other words, the data support the hypothesis.

Figure 2.3 Disambiguating Picture

Participants in the Context condition viewed this picture first before listening to the ambiguous story.