THE GREAT COURSES®

How We Learn

Course Guidebook

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Professor Monisha Pasupathi is an Associate Professor in the Department of Psychology at the University of Utah, where she has served on the faculty since 1999. She completed B.A. degrees in Psychology and English Literature in 1991 at Case Western Reserve University and, having found that academia was her natural habitat, immediately went on to complete her Ph.D. in Psychology at Stanford University in 1997. She subsequently completed a postdoctoral fellowship at the Max Planck Institute for Human Development's Center for Lifespan Psychology between 1997 and 1999.

Professor Pasupathi's research examines how people of all ages learn from their experiences, with a particular focus on learning about the self via telling stories. People tell stories about their everyday lives, and as they do so, they draw conclusions about what they are like, what others are like, and how the world works. The audiences for these stories contribute by supporting the stories, but also by challenging them.

Professor Pasupathi teaches courses in research methods, adult development and aging, and social and personality psychology, along with an occasional specialty class in memory and self, to approximately 100–150 students per year. She is especially proud of her research methods courses, which she views as providing critical skills in the evaluation of research to any member of society; this aspect of her teaching has given her a strong side interest in scientific reasoning and literacy.

During her time at the University of Utah, Professor Pasupathi has received recognition for her teaching on 3 separate occasions. She was named Best Psychology Professor by Utah's chapter of Psi Chi, The International Honor

Society in Psychology. Psi Chi also awarded her the Outstanding Educator Award and Favorite Professor Award.

Professor Pasupathi coedited the book *Narrative Development in Adolescence: Creating the Storied Self*. She has also authored and coauthored chapters for more than 10 books, including *The Handbook of Aging and Cognition*, *Identity and Story: Creating Self in Narrative*, and the *Encyclopedia of Human Relationships*. Her research has also been published in scholarly journals, including *Psychology and Aging*, *Journal of Personality and Social Psychology*, and *Developmental Psychology*.

Since her graduate years, Professor Pasupathi has been delivering community lectures in an effort to make psychology relevant and interesting to the public. Her first talk, given to the Kiwanis Clubs of Menlo Park, focused on marriage and aging. Most recently, she worked in collaboration with neuroscientist Christopher German and The Leonardo interactive museum to craft a public presentation on the relationship between self, memory, and the brain. She also works with the Utah Symposium in Science and Literature, an organization that brings innovative, integrative presentations connecting science and the arts to a general public audience in Salt Lake City.

In her nonwork life, Professor Pasupathi enjoys the mountains, reading, cooking, and the many stories that her children, husband, and extended family provide. You can learn more about her and her research at http://www.psych.utah.edu/monishapasupathi. ∎

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LECTURE 24

SUPPLEMENTAL MATERIAL

How We Learn

Scope:

Learning—the acquisition of new knowledge or skills from experience—is a complex process. Without learning, you couldn't walk, speak, operate a computer, drive a car, or tell a great story. This course explores the newest research on how we acquire new knowledge and skills—from birth through late life. We now know that learning depends on what is learned, how and why it is learned, and by whom, and each of these issues will be examined throughout the course.

In the first segment of the course, you will encounter the early efforts to explain learning in terms of associations, rewards, and punishments—and where those early efforts fell short. The history of research on learning presents an interesting story because for a while, researchers believed that learning was a single simple process that could be applied across various species, including pigeons, rats, dogs, and people.

In the second segment, you'll learn that learning is not passive: It doesn't involve a pouring of information into an empty brain, and there's no tabula rasa, or blank slate. You will discover how learning depends on what we already know—for adults and for newborns—and you will determine what newborns must know at birth in order for them to learn so much so quickly.

The third segment of the course examines how we learn different things—a second language, a dance, a new city, a problem-solving strategy, a body of scientific knowledge, and how to tell stories. Learning can involve skills or knowledge and visual or verbal information, just to name a few distinctions. Not everything is learned in quite the same way, and not everything is equally easy for us to learn. We learn motor skills and language in ways that have both overlaps and differences. We learn how to get around a city in ways that are comparable to learning how to tell a story—but that are also distinct. The broad view of this section will allow you to draw some conclusions about what is true for learning across different areas and what is specific to particular types of learning.

The fourth segment of the course explores the idea of metacognition, or knowledge about learning. You will discover some of the basic cognitive abilities that allow learning, and you will examine the way in which we learn both information and context—but not equally well. You'll discover when and how paying attention improves learning, and perhaps most importantly, you'll analyze people's ability to judge their own learning and to make strong strategy choices about how to learn better. You'll also consider the role of emotion, motivation, and goals in learning: Is it better to learn when you are in a good mood? Do you have to be interested in things to learn them?

Finally, in the last segment of the course, you will consider how learning is different for different people. Recall a learning situation in which you have envied the people around you, who seemed to learn so effortlessly and so quickly. What is the difference between you and those other individuals? Is it that they are smarter? Are they more motivated by the material they're learning? Do they have different learning styles that fit better with the instructor? Is it because they're older and more experienced or younger and more energetic?

By the time you complete this course, you will appreciate the incredible breadth of what we learn in our lifetimes, understand the commonality and diversity across that learning, and perhaps understand how you can maximize both how much you learn and how much you enjoy learning. ∎

Myths about Learning
Lecture 1

Although our intuitions about how we learn may have grains of truth, they're often—to a larger extent than we realize—misconceptions, and they're based on an imperfect understanding of people and animals as learners. In much of this course, we will consider the ways in which we are right and wrong about how we learn. In this lecture, we'll define what it means to learn, and we'll discuss some concepts that are relevant for learning—that are maybe close to the idea of learning but are not quite the same—such as development and memory.

Myth 1: Learning is aware and purposeful.
- We don't always have awareness of the learning process or its outcomes. In addition, we learn all the time and we often do so without awareness that we're learning—without actually meaning to learn anything at all.

- For example, if you suddenly start wearing a different pair of glasses to the grocery store than you normally wear, your favorite cashier might not recognize you because, without realizing it, what she had learned about the way your face looks was connected to a specific pair of glasses. Many people experience this from both sides—being recognized or not, or failing to recognize someone—when one minor thing has changed.

Myth 2: People, especially intelligent people, basically already know how to maximize learning.
- This myth is related to the idea that learning is largely something we're aware of and, therefore, something we know how to optimize. In fact, there's evidence that people choose less-than-ideal strategies for learning.

- Furthermore, our judgments of what we've learned well, what we don't yet know, what we do and do not need to practice are not as accurate as they could be.

- For example, our experience of learning as effortful may mislead our judgments of whether we learn something, and consequently, our ideas about what we need to practice and what we can stop practicing are also wrong.

Myth 3: When learning is going well—when we're really learning—we feel confident, successful, and clear.
- In fact, the learning process is not quite that straightforward. Moments of confusion, frustration, uncertainty, and lack of confidence are part of the process of acquiring new skills and new knowledge.

- However, learning is going on all the time—even in those less confident moments—and sometimes those moments are necessary before we achieve a new level of understanding.

Myth 4: Emotion is a problem for rationality, and therefore, getting emotional messes up learning.
- The idea that getting emotional messes up learning or makes it difficult to learn may have a grain of truth, but it is probably more accurate to view emotion as changing the orientation we have toward learning, narrowing our focus when we're learning, or broadening that focus.

- When we are feeling angry or anxious, that may help us focus our attention very narrowly. When we're feeling good, we're likely to broaden and make new connections more easily—and maybe even make more creative connections. Different types of learning and different learning situations may call for one or the other kind of focus. Additionally, emotion can help or hinder learning, depending on what emotions we're talking about and what is being learned.

Myth 5: If someone doesn't find something interesting, he or she won't or cannot learn it.

- We often think that interest helps learning. Of course, it's true that being interested in learning something can help us learn it, and people have things they can do to cultivate interest and engagement. There are ways to increase your motivation to learn.

- It turns out that foundational learning can actually foster the development of interest. In other words, we usually think interest helps learning, but learning can also help us develop an interest—another reason to stick it out through early frustration.

Myth 6: People learn from getting rewarded and punished.

- Many of us think that we learn from consequences, and we sometimes treat our pets and our children in precisely this way. However, people and animals explore their worlds for the sake of learning.

- In addition, learning seems to be an innately motivated action. For example, infants who are learning to walk experience a lot of painful consequences, but this doesn't deter them from carrying on with the project of learning to walk.

- For a dog who learns to sit when you say "sit," perhaps after many treats, the reward is not necessarily what drives learning. The dog actually might figure out what you want relatively quickly. Instead, what the reward does is encourage the dog to demonstrate what it has learned.

Myth 7: Intelligent people learn more easily and better than less intelligent people.

- This myth seems so logical, that there are some of us who are smarter than others—those people who do very well on IQ tests—and that having a higher IQ means you have an easier time learning new things.

- However, being smarter by scoring higher on IQ tests might actually mean you've already learned more—not necessarily that learning was easier for you in the first place.

Myth 8: Learning is like opening up your brain and having stuff dumped into it.
- Learning is not passive, and it doesn't happen on an empty brain. We are transforming information in our environments all the time in order to learn; some of those transformations are completely without our awareness.

- In addition to that transformation that is occurring, learning actually depends on prior knowledge and assumptions because the transformations we make allow us to connect new experiences and new information to what we already know.

Myth 9: People of all ages learn basically the same way; learning is learning.
- There is an enormous amount of evidence that people of different ages learn somewhat differently. First, if learning depends on prior knowledge, then children and adults have different prior knowledge of the world.

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Children learn from their experiences to wait patiently for their turn to speak in class.

- In addition, the ability to reflect on what we are learning—to think critically as we're in the process of learning—develops. The brain matures from birth to adulthood in ways that allow us to engage in critical thinking about evidence and sources of information as we learn. In childhood, the brain has more of a limited capacity for that kind of critical reflection, which in turn affects how children learn.

- Also, the learning limitations go in both directions. There are things that babies are good at learning and adults are not so good at learning—such as language—and there are things adults are capable of learning and young children are not so competent at learning—such as evidence-based reasoning—even with a lot of help.

Myth 10: You can't teach an old dog new tricks.
- This myth implies the idea that learning new things is only something children do well. However, given good health, even people who are very old are able to learn new things.

- Learning does change as we age. There are changes in how quickly we learn, and there are changes in what we care about and are interested in learning. Therefore, it's not that learning is the same in old age as when we are young; instead, learning is possible for people across the lifespan. Old dogs are always learning new tricks, provided they want to do so and provided they take the time to do so.

What Is Learning?
- Dictionary definitions of learning define it as a change in a person's understanding, knowledge, or abilities that arises from the person's experience.

- This definition encompasses things we learn consciously and know that we've learned—such as changes in understanding and knowledge—and things we might acquire in a less conscious way—such as learning how someone's face looks. It focuses on change, which gives us a way of thinking about how to tap into learning, and it emphasizes that learning comes from experience.

- At the end of the course, we'll revisit the definition and we'll think again about whether it encompasses the points that we've raised along the way.

Learning versus Development and Memory

- Development can be defined in ways that actually include learning as one of the ways development happens—and in ways that exclude learning from the idea of development.

- In this course, we will view development as referring primarily to brain-based maturation, changes in abilities that are going to happen regardless of the specific experiences that a child has.

- Most changes from childhood through old age combine developmental processes, such as the maturation of our brains with specific experiences that we learn from. Therefore, most of what changes about our lives involves some combination of maturation and learning.

- Memory is also not the same as learning. Memory is our ability to store and recall past experiences in various ways, and learning is the acquisition of new information and abilities.

- Without memory, we can't keep what we learn. In fact, without memory, there would not be learning. In many cases, we know we've learned because we can recall information. Therefore, in many cases, memory is how we know people have learned.

- Learning is your acquisition of new knowledge, but to say that knowledge has been acquired, we also mean that you can store and recall it using memory systems.

- Learning both changes the brain and depends very intimately on the changes that have already occurred in the brain—our store of knowledge. Learning is a way of changing the brain, and the brain allows us enormous sophistication and flexibility in the learning process.

- The main point of this course is that learning is a complicated process that depends in part on what is being learned, how and why, and by whom.

Question to Consider

1. Consider learning experiences you would term successful as well as those you would term failures. Consider the sense of effort versus ease you had and the emotional qualities of the experiences. Consider whether you had an easy time motivating yourself or struggled to stay with it. What are the characteristics of good and bad learning experiences?

Why No Single Learning Theory Works
Lecture 2

Can we have a theory of learning that applies to everyone learning and everything to be learned? This was arguably the ambition of early learning theories. Researchers developed and actively tested these theories through the 1960s, and the work they did continues to inform our understanding of learning processes even today. In this lecture, we will get a sense of just how much we learned about learning using these early approaches, but we will also discuss how these approaches fell short of explaining the vast array of learning that people and animals do.

Classical Conditioning

- The kernel of learning theories is that learning in everyday life involves associating two things with one another. For example, an infant learns that the parent's appearance signals comfort and food. How we acquire these associations between two different stimuli is important, and it's a foundational question in the science of learning.

- Early studies of this type of learning called it classical conditioning, which looks at learning of the association between two stimuli, or things that stimulate a response, by capitalizing on instinctive or reflexive responses. These are behaviors that aren't voluntary—such as blinking or salivating—and they seem to be built into an organism.

- In the most famous work on classical conditioning, Ivan Pavlov looked at salivation, which is a reflexive response to having food placed in your mouth—an effect that occurs in both dogs and humans. Pavlov paired two events to see if the dogs could acquire the association.

- For Pavlov, the first event was food. It was a meat powder that he gave his dogs, and he called this the unconditioned stimulus. When the dogs were given the meat powder, they produced saliva, and Pavlov called this the unconditioned response. However, prior to giving the dogs the meat powder, Pavlov also rang a bell. The bell tone was the conditioned stimulus. Salivating to the bell, rather than the food, is what Pavlov called a conditioned response. This indicates that the dog has acquired an association between the bell tone and the arrival of the meat powder.

- At first, even though the bell is occurring right before the arrival of food, dogs don't salivate to the sound of the bell, but after a number of exposures to the bell, followed by the meat powder, they start to do so. The salivation to bell is a conditioned response, and it shows the dogs have come to associate that bell tone with being given the meat powder.

- What it takes for a dog or any animal or human to acquire associations like this are three things: repetition, temporal contiguity, and differential contingency.

- Repetition is being exposed—often multiple times—to the pairing of two stimuli. Temporal contiguity means that the two stimuli have to happen close enough together in time. Differential contingency means that when the conditioned stimulus occurs, the unconditioned stimulus will come.

- Once an association is learned, the animal or human may generalize that association—that is, apply that learning to similar situations. If the associations are too specific, the kind of learning they support won't be very useful. Associations need to accommodate some variability to be truly useful.

A Few Questions
- Are there factors that make the learning of associations stronger? What is meant by the term "stronger" is that the conditioned response is either more intense or it's more consistently produced.

- If a conditioned stimulus is uniquely predictive of an unconditioned stimulus, then conditioning is stronger than when that's not the case. If only one sound signals one event, the arrival of the meat powder, the conditioning is stronger than if food arrives after the dog hears many different sounds.

- In fact, if you try to add a second conditioned stimulus when the animal has already learned the first one, they don't actually learn the second one. For example, if Pavlov's dogs are given both a light and the bell, they don't learn to salivate to the light because it's redundant. In other words, learning is efficient.

- Are there factors that make the learning of associations weaker? If you repeatedly present the conditioned stimulus without the unconditioned stimulus, you'll get a decline in the likelihood that the animal is going to give you the conditioned response. If you keep ringing the bell and there is no meat powder, the dog will stop salivating.

The Little Albert Experiment
- Associations don't always involve responses we view as neutral, such as salivation. One of the most famous examples of classical conditioning involved John B. Watson and Rosalie Rayner's conditioning of fear in a young infant that they called Albert.

- The goal of the study was to get Little Albert to respond to rats with fear by being presented with rats in conjunction with a loud, unpleasant noise. Eventually, Little Albert acquired a fear reaction to rats, and he generalized that fear reaction to white, furry animals of all kinds.

- The point of the Little Albert experiment was to demonstrate that phobias were learned behaviors—not inborn as had been previously thought. The experiment also suggested that you could treat phobias the way you would extinguish any conditioned response—by extinction.

Problems with Classical Conditioning

- With classical conditioning, there's very little attention to the awareness of learning or the idea that people may actively try to learn something, which we know they do, and there's no attention to the idea of feedback.

- A comprehensive treatment of learning has to account for the many cases in which we aren't passive recipients of environmental events, but actively altering the environment to achieve particular goals.

- The idea that there are consequences of our behavior—that rewards and punishments are important aspects of how we learn—is a very entrenched idea that is used in many different situations. This idea matches intuitions we have about the pursuit of pleasure, and it also seems to take into account the fact that we do consider consequences when we are engaging in our behavior.

Operant Conditioning

- Around the turn of the 20ᵗʰ century, Edward Thorndike observed cats figuring out how to open a latch and escape from their cage into an adjacent enclosure that had a large dish of salmon. At first, the cats had to engage in trial and error to accomplish the task, but once they figured out how to open the latch, latch-opening behavior increased.

- Thorndike articulated what he called the law of effect as a rule about how behavior might be governed by its consequences. The law of effect implies two things: An important class of associations that we learn are the ones between what we do and the consequences of that behavior, and we change our behaviors when we've learned those contingencies.

- Thorndike also noted that we can have positive or negative consequences, and they can either occur or cease, and behavior should vary accordingly, provided we learn the behavior and consequence associations accurately.

Good students learn to associate dedicated study habits with the reward of high grades.

- Following this reasoning, researchers began to conduct experiments to see how they could alter behavior by changing or controlling the consequences that were attached to behavior. This research area was termed operant conditioning, and it differed from classical conditioning because it emphasized associations between behaviors and consequences—rather than associations between two stimuli.

- The assumption of operant conditioning is that when an animal is rewarded for a behavior, increases in the behavior show that the animal has learned to associate the behavior and reward.

- As with classical conditioning, it's important that the reward be contingent on the response for the person or the animal to learn the association. The reinforcer has to follow the behavior when it occurs. However, you can alter the rewarding to maximally shape behavior—to form the strongest association.

- On a fixed ratio schedule, every time the animal presses the lever 10 times, it gets a food pellet. On a variable schedule, the animal gets a food pellet, on average, when it presses the lever 10 times—but the actual number of lever presses varies over time. This creates a bit of uncertainty; you never know quite when you're going to get a reward.

- If you want to have someone engage in a behavior maximally, a variable ratio schedule is a very good one to use. In animal research, the animal will respond at a high rate all the time because it can never tell exactly when the reward is going to come again. Gambling with slot machines is an example.

Problems with Punishment
- With punishment, because the behavior you're going to punish is already happening, it must already be rewarded in some way— according to operant conditioning researchers. Unfortunately, it is not always very easy to know what that reward is, but you need to figure it out before your punishment will work.

- Punishments slow down people's responding, even when they are given in the presence of rewards, and they also will lead people to find an alternative way to get that reward.

- Punishment works, but it works best when it is maximal, immediate, and not introduced in mild form. When we punish children, we often violate these principles. We sometimes delay punishment, or we start with milder punishments and we work toward more severe consequences. What the research says is we have to jump on bad behavior with as severe a response as we think appropriate.

Complications with Punishment and Classical Conditioning
- The theories of punishment and classical conditioning cannot explain what is rewarding or reinforcing outside the narrow range of innate drives, such as hunger and thirst. For example, some animals will press a lever just to make a light turn on.

- Another complication in what counts as a reward comes from research that suggests that behaviors that are more often chosen in a free-choice situation are reinforcers for less frequently chosen activities. For example, given a choice between running several miles and eating a piece of cake, all else being equal, most people would take the cake. The cake can then be a reinforcer for the running, but not vice versa.

- Some stimuli become reinforcers because they're associated with desirable items. The clearest examples of this are token economies. Money is the most famous token economy, in which we have these papers that we can exchange for things we actually want.

- Simply having control over events is reinforcing. In addition, there's evidence that people learn without any rewards. For example, child development researchers have shown that children will even imitate someone who's clearly failing at their intended goal.

- One of the most difficult parts of learning theory initially was that researchers wanted to avoid considering anything that wasn't directly observable. However, a person's own ideas about the world play a role in whether a reward is really a reward.

- Considered this way, it makes more sense that control over the environment is itself rewarding and that animals and people exhibit latent learning—learning that's already occurred but they haven't yet demonstrated in their behavior. It also makes more sense for explaining how we learn complicated things—such as token economies—and for understanding the paradoxical features of punishment.

Suggested Reading

Beck, Levinson, and Irons, "Finding Little Albert."

Powell, Symbaluk, and MacDonald, *Introduction to Learning and Behavior*.

Rankin, et al., "Habituation Revisited."

1. Studies of classical and operant conditioning suggest some useful ways of training a pet to do a trick or of training ourselves to do something new. Consider how you might apply principles of reinforcement to change a habit you'd like to alter.

2. Can you explain how people understand that "the dog bit the man" and "the man bit the dog" mean different things using only the idea of learned associations between stimuli or between stimuli and responses? Why or why not?

Learning as Information Processing
Lecture 3

In the last lecture, we learned that in attempting to create a theory of learning that avoided representations, expectations, and other immeasurable concepts, researchers in the field of learning actually became increasingly incapable of explaining even some pretty straightforward concepts—such as learning without rewards or the fact that rewards are relative. In addition to the issues that were raised in the last lecture, the restriction on talking about mental states and processes meant that learning theories were unable to explain some very important phenomena in the area of language processing.

Information Processing

- Consider the following three sentences: We have to be at school by 6 pm. The performance begins at 6 pm. At 6 pm, the play will start. They all mean more or less the same thing, but they are three different stimuli from a behaviorist and conditioning approach. It is difficult to explain how these three different sentences are understood in the same way by the person hearing them.

- If we only have behaviorist and conditioning approaches to work with, then we have to resort to the very cumbersome idea that over time all three sentences have become associated with the same response—showing up at school by 6 pm. That's problematic because once you have one stimulus associated with a response, it's not easy to learn a new association to that response.

- Once we allow ourselves to talk about meaning and representations, however, it's very easy. While the surface form of the three sentences is different, the underlying meaning for the person—the information they contain—is the same, and they're going to result in the same behavior.

- Many other aspects of language use were difficult to explain with behaviorism, such as the way people can generate many different sentences that are all grammatically correct. Early learning theories require that we were exposed to those sentences before we could generate them, but this isn't the case.

- People make sentences that nobody has ever heard before, and a person's ability to create a new sentence only works if we have the idea of rules, which aren't observable parts of the environment. The idea of rules means we have to imagine what's going on inside people's heads, and that's completely unacceptable in a classic behaviorist approach to learning.

- As conditioning paradigms were running into trouble, there were some exciting developments going on in computing, including the development of the first computers, which gave rise to a corresponding development that's referred to as information theory.

- The language and concepts in the computing world turned out to be helpful in thinking about the way the human brain might learn. Information theory emphasizes how information is coded and recoded and how it can be decoded or understood as it gets transferred across various media.

- From this perspective, we can think about learning as the acquisition of new information and the ability to use that information in some way—to repeat it, for example. In this way, learning occurs as people take in, store, and then use information.

- An information-processing approach to learning means that learning happens as people encounter information, connect it to what they already know, and as a result, experience changes in their knowledge or their ability to do certain tasks.

- The kind of information we encounter can actually be quite varied, and both learning and the demonstration of learning can be thought of as translations of information from one medium into another.

- An information-processing approach identifies different stages of the learning process. Initially, new information must be encoded—that is, translated from perceptual experiences into a representation in the mind. Once it's in the mind, we may or may not further work with the representation; this can be compared to the process of a rehearsal.

Verbal Learning
- These two stages, encoding and rehearsal, represent aspects of learning that can vary. There are many ways we encode information, and there are different ways we rehearse it once we have it encoded. On some later occasion, we may have to retrieve that representation in order to demonstrate our new learning. The basic approach to studying learning from this perspective is often verbal learning—that is, learning lists of words.

- When we ask people in verbal learning paradigms to learn lists of words or word pairs to demonstrate their learning in tests of memory, we divide the learning process into three information-processing stages: encoding, storage, and retrieval.

- During encoding, people are taking in new information and are making sense of it. For example, you're both hearing what someone else is saying and drawing on your past experiences to transform the sounds the other person is making into something meaningful and understandable.

- In fact, encoding operates through a variety of short-term information stores, and within each of those stores, information is being transformed. Researchers call that storage space working memory. Within working memory, we think about the meanings of words and link them to memories we already have.

- Processes of rehearsal also draw on our established knowledge, which you can think of as long-term memory. Encoding is central to our understanding of learning today, and differences in encoding matter for how well we learn.

- Storage, in an information-processing account, refers to keeping information we have learned over time. The storage part of the process of learning is actually the most difficult to test, measure, or observe.

- During retrieval, people make use of the information they previously learned. For example, you might be asked to recall information, to recognize something previously learned, or to demonstrate use of prior learning without even thinking about it.

- Retrieval is not the same as learning, and we might think of retrieval roughly as memory. Retrieval is often one of the only ways we have of knowing that something has been learned.

- Retrieval is not only a demonstration of past learning; it's also a re-encoding. That is, every time you recall information, you re-encode it. You retrieve it and use it, and the information is actually changed because you've retrieved it and used it. In this way, although retrieval often gets thought of as a way of demonstrating previous learning, it turns out retrieval is also an important way to improve learning over time.

Information Processing versus Conditioning
- Conditioning couldn't explain why water is rewarding sometimes and not other times. Information processing says that encoding is a function both of the stimulus—the water—and the prior experience of the perceiver, and experience varies over time. When recent experiences have left a person or animal hungry, food rewards are enticing. When this is not the case, food rewards are less appealing.

- In addition, what rewards us and reinforces our behaviors varies from one person or animal to the next. Because of this, one major factor in learning involves the way that our previous experience changes how we encode information.

- Conditioning paradigms have a difficult time explaining why people would learn without rewards or incentives, although people do. Information-processing theories, by contrast, suggest that we're fundamentally oriented toward making sense of our worlds and that information is its own kind of reward.

- In conditioning work, variability in how people or animals learn was limited to variations in the way stimuli were presented or that responses were rewarded or punished. By contrast, in an information-processing paradigm, we can actually look at variability in how people engage with the material to be learned. We can ask, in limited ways, what's in the subject's head. When studying humans, we often do this with verbal materials.

- Consider that some things don't help us learn. Numerous studies show that simply repeating information over and over doesn't actually help us learn it very effectively. Unfortunately, it turns out that merely intending to learn a list of words also doesn't help us learn them.

- While intentions to learn material and simple repetition don't seem to help us, something called elaborative encoding does. Study after study reinforces this finding, and it has direct applicability to a lot of the learning we do.

- In practice, this means that going over notes is less effective than reading and thinking about how material can be connected to other things we already know; thinking about clever mnemonic devices that would help us recall material; or otherwise engaging in deeper, more elaborated thinking about the material we're trying to learn.

- Elaborative encoding works better for learning because, in most cases, it approximates how we're going to use the information we're trying to learn. A phenomenon called transfer-appropriate encoding shows that the more your learning method approximates the way you're going to need to use the information you're learning, the better your learning will be. In fact, if you're learning specifically to be able to do well on a test, testing yourself over and over again represents a way to learn material that's very effective.

Retention testing is a way of using the material we've learned; for many of us, we retention test ourselves on reading every day.

- Every time we recall things we've learned, that occasion of recall functions as a new learning episode. In other words, when you engage in retrieving learning, you give yourself another chance to encode. There is a phenomenon called hypermnesia that shows just how effective repeated retrieving can be for learning.

- Hypermnesia means that when you test retention—when you engage in testing over and over again—you actually end up increasing what you remember over time. This is a very powerful and important idea for those of us who want to continue to learn things or to remember what we've already learned.

- Research in this area suggests that different types of information may be differentially easy or difficult to learn. In addition, studies suggest that pictures may be easier to learn than words, which is why so many memory techniques make use of visual imagery to help people remember things.

Learning and Forgetting

- Material we learn is forgotten when it's not used, and retention testing is also a way of using the material we've learned. In some cases, as it is with reading, we retention test ourselves every day. In other areas, such as with foreign language learning, we may not very frequently make use of that past learning, so it's not surprising that we end up forgetting or losing much of what we initially learned.

- Information-processing approaches to learning give us much more flexibility than classical or operant conditioning theories about learning. Information processing allows us to think about how learning changes depending on who's doing it and how they're going about doing it.

- The idea of transfer-appropriate encoding also reminds us that why we're learning is important, and matching how we are learning for the purposes we have in mind is going to be important for enhancing the effectiveness of our learning.

- Perhaps the most important part of the information-processing approach, however, is that information-processing approaches demand that we consider not just the material to be learned, but also the past experiences and expectations that we bring to that learning experience. In other words, there is no tabula rasa; there's no blank slate.

Suggested Reading

Baars, *The Cognitive Revolution in Psychology.*

Question to Consider

1. How might information-processing ideas about learning be applied to learning a new dance or hoping to improve one's golf swing?

Creating Representations
Lecture 4

We seldom, if ever, learn passively by letting things wash over us. Learning does happen without our awareness, but even in that case, learning happens as we're engaged in purposeful action: We're pursuing other goals, and the learning that happens in those circumstances is affected by the goals we're pursuing. Furthermore, we learn in addition to everything else we already know, and what we already know changes our experiences as we learn. In this lecture, we'll discuss goals, or purposes, and how they affect learning. Then, we'll consider how past experience shapes current and future learning.

Learning and Motivation
- If we think about learning in terms of information processing, we can draw an imaginary line from a stimulus in the environment—a piece of information, an image, or a sound—through a series of transformations and repetitions based on previous knowledge and experience. That line ultimately ends up in learning.

- The stimulus can be anything defined in terms of energy—such as sound waves or light waves—and that energy is transformed into a sensory experience by our sensory systems. It is then transformed further into a perception, and we may combine perceptions into even more complex representations of our surroundings or into complex actions and reactions. This is the process of encoding.

- Representations and actions that we store and can then generate on our own—independently of the environment and independently of a stimulus—are considered learned. This is the process of retrieval.

- Goals shape what we learn as we go through experiences, and they affect our imaginary line at each stage in the process. Sometimes the goal is simply to learn about our environment and what the available options are. At other times, the goal is more narrowly focused, and the learning that occurs happens more incidentally with possibly more limited usefulness. Learning is also shaped by the goals we pursue as we engage with our environment.

- We learn what we need to learn to engage in our everyday actions. When we don't need to learn, we may actually not learn anymore. For example, when the goal of being able to stay in touch with friends can be met without memorizing phone numbers, we no longer invest effort, time, or energy in learning the numbers, and we actually don't learn them.

- Psychological research has shown that purposeful behavior shapes our learning, even when learning isn't our central purpose. However, human beings and other animals engage in a lot of spontaneous exploration. In fact, the exploration of our environments is a major motivating force. In other words, we often do have a chronic goal of learning.

Exploration as a Motivator

- In the 1950s, psychologist Kay Montgomery proposed that animals have two conflicting motivations: a drive to explore, or curiosity, and a fear of the unknown. He posited that the curiosity drive is innate and that it's aroused by novelty.

- In one study, Montgomery and his colleagues showed that rats would learn a simple maze much more quickly if they were rewarded with the opportunity to explore a more complicated maze. Therefore, getting to learn something more interesting actually serves as a reward.

- Montgomery also showed that rats who had a more complicated and rich environment when they were young actually become interested and curious in complicated environments—but not in simple, new environments. To some extent, what's novel and what stimulates curiosity depends a little bit on what you've experienced up until that point in your life.

- Human infants begin exploring almost from the beginning of life, even when their ability to move, see, hear, smell, and taste are very limited. This exploration has many functions, but it seems that it's rewarding for babies to simply understand their environment and what it offers.

- One of the biggest changes in a baby's behavior happens at the point where the baby is able to grasp an object. Grasping lets babies link how an object feels in the hand with how it looks to the eyes. Once babies move from grasping to crawling or walking, there is no stopping their exploration.

- You may think that exploration is the province of the young, but the act of exploration—the act of learning something new about your environment—is a motivator for most of us in our daily lives, at least in some areas. Exploration is a lifelong possibility.

Learning and Prior Knowledge
- The purposes we have as we go through our day and the purpose of exploration itself are not the only things people bring with them to a learning situation. Learning is not only purposeful; it's also driven, to some extent, by what we already know.

- There is no tabula rasa in learning. In other words, what we learn doesn't just come in and imprint some as-yet-unused piece of the brain; instead, what we learn is a result of what we've already learned.

- Just as with goals, along our imaginary line representing information processing, there are numerous points where we might see the importance of past experience in shaping present perception and representation—and by extension, learning.

- One point along that continuum is in the transformation of stimulus energy into sensation and perception. Some of the most compelling experiments in this area look at the connection between early deprivation and the ability to sense or perceive parts of the visual environment.

- In these studies, researchers vary whether a particular experience happens or doesn't happen, and then they look at whether that experience matters for a later ability to perceive or sense the environment. For example, it turns out that experience matters quite a bit for later visual perception.

- An example from visual perception concerns the ability to recognize faces. Interestingly, when people grow up in ethnically and racially homogenous environments, they're actually less capable of recognizing individual faces of people who come from a different racial or ethnic group—and possibly of associating names with those faces. This phenomenon is called the same-race bias.

- This bias can be overcome with exposure: As we see many diverse faces, we become better at discriminating between individual faces from people in an ethnic group that is different than our own. In fact, this kind of perceptual learning—the ability to tell the difference between different stimuli with exposure—happens in many contexts.

- Perception—the basic, initial phase of information processing in learning—is affected by our past experiences with stimuli. There is no tabula rasa, not even at the very beginning of information gathering for learning.

- Let's move a bit further along that processing path to the point where people need to take perceptions and combine them to create some meaningful representation. We learn some very interesting things about meaningful representation in early learning experiments that involve memory for words—and for illustrations.

- People have to make use of their own prior knowledge in order to use categories to help them learn and remember lists of words. Once they do so, they are prone to some distinctive and interesting errors. For example, suppose you are presented with the following list of words and are asked to learn them: bed, nightlight, reading lamp, pillow, blanket, dream.

- Later, when you are asked to recall the words you just learned, you're very likely to recall the word "sleep," even though it was not on the list. This is a very robust finding, which means that it is a very easy finding to repeat with different participants and different studies.

- Remembering that you learned the word "sleep" in this list is what researchers call a false memory. You spontaneously used a category you have—things related to bedtime and sleeping—to organize the words you were given as you learned them. Later, this organization actually makes you better at remembering the items that were on the list. It also makes you vulnerable to the error of remembering that "sleep" was on the list.

Categories and Scripts
- Just as our knowledge about categories helps us organize otherwise chaotic information, our knowledge about complex events and objects in the world, known as our schemata, help us learn from experiences.

- Schemata are defined as abstract knowledge structures, and they include things like plans and event sequences, which are also called scripts. Just as in a play, a script tells you what happens, in what order, for some type of event.

- These knowledge structures were originally conceived of in computer science—as people tried to figure out how to get computers to process information—and then they were applied to research on how human beings process information.
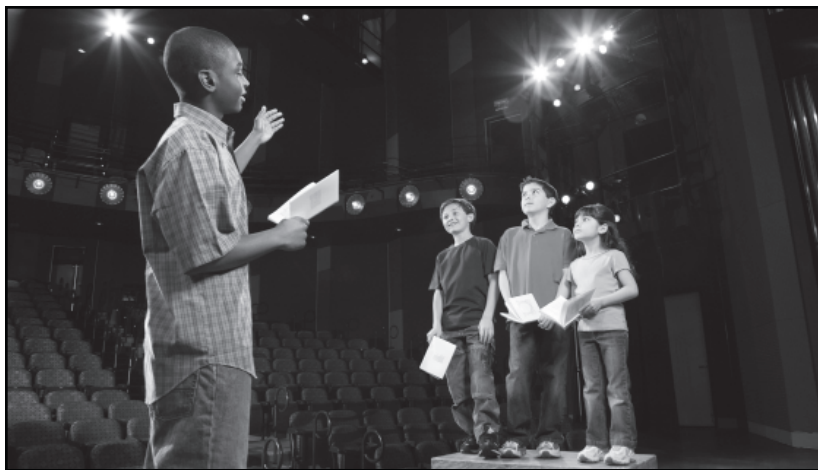
Just as in a play, a script tells you what happens, in what order, for some type of event.

- Roger Schank and Robert Abelson are two pioneers in this field, and some of their early work involved trying to make computers that could read and understand prose based on prior programming with a script. Reading and understanding are not quite the same as learning, but they are important steps in encoding.

- There are a variety of ways of testing the idea that there are scripts in people's heads—just as with testing whether there are categories in people's heads. In a sense, scripts are like categories, but scripts also have information about serial order, or the expected order in which events occur.

- One way of testing the idea of scripts involves asking people to learn and recall events and looking for false intrusions of script-relevant events that people were never told about.

- Furthermore, when people are asked to generate a script, or to draw inferences about what happens next in a story, they're more likely to choose something that's pretty central to the script rather than something that's more peripheral or could be left out.

- If you were asked to generate a script for eating out in a restaurant, you would include items like being seated, reading the menu, choosing something, waiting for the food, and asking for the bill. However, you probably wouldn't list things like visiting the bathroom or assessing the quality of the chairs because these are peripheral to the main idea of having dinner out. Leaving these items off your list suggests that scripts aren't just a memory for eating out, but they're actually a list of rules and events that are central to the event of eating out.

- We approach any learning situation with prior knowledge and with beliefs about categories and scripts, and these influence what we perceive, understand, learn, and later remember from material we're trying to learn. Two of the prominent features of prior knowledge are categories and scripts, but there are other kinds of prior knowledge—prior knowledge about body movements and scripts for muscle movements, for example—that also qualify as kinds of schemata and that also affect learning.

Suggested Reading

Bartlett, *Remembering*.

Questions to Consider

1. Categories and scripts are both friend and foe to learning in that they serve as aids to learning new material, but they can also produce errors in our learning and memory. Considering your everyday life, how important are the errors that are produced by category- or script-based distortions in learning?

2. Can you recall a time when you had to learn a new event script? What was that time? How did the experience unfold?

Categories, Rules, and Scripts
Lecture 5

I n the previous lecture, we discussed how our minds are not a tabula rasa—that the way in which we learn is influenced by our prior understanding of categories and events. We also learned that those prior understandings can be called schemata, and scripts are one kind of schemata. This begs the question of how those things are learned and what precisely we're learning in the first place. This is the topic we're going to take up in this lecture on categories, rules, and scripts.

Categories and Perceptual Learning
- Categories are critical well beyond the role they play in learning. For example, knowing whether something is edible or whether a person can be trusted are category judgments.

- One of the first demonstrations of category learning occurred in the area of perceptual learning, which is a very important type of learning. For example, perceptual learning is what permits children to distinguish between the letters d, b, p, and q—all of which look pretty similar, especially to a child learning to read.

- Initially, perceptual learning was thought of as a memory-based process. However, in the 1950s, James and Eleanor Gibson argued that what we learn through perceiving—somewhat automatically— is to perceive increasingly more aspects or features of what we're looking at, and as a consequence, we can make more fine-grain distinctions among things we're looking at.

- Discriminating between different things is a fundamental precursor to being able to understand categories, which exist because certain distinctions matter while others don't. Furthermore, prior learning about categories has many implications for what we learn.

- Initial work on perceptual learning that was done by the Gibsons showed that just looking at material over and over again increases the extent to which we can perceive differences in those materials. Because judgments of similarity and difference are fundamental parts of category learning, perceptual learning is a basic step in acquiring categories.

- The results of perceptual learning studies show that all age groups improve at the task over time. They also show that once you're an adult, your ability to quickly acquire perceptual categories is significantly improved. In addition, the learning that people do isn't in response to rewards.

- Human beings and monkeys appear to acquire categories in stages. First, we master what's typical, and then we seem to learn the strange examples. The fact that we do this in stages leads to the question of how we are managing our learning.

Early Theories of Category Learning
- Early views in the area of category learning were called exemplar theories, and they focused on memorizing each example of a category individually as a member of that category. This would be like learning the association between each individual fish and the overarching category of trout.

- The prototype theory account stated that we first have an experience with a category—for example, fish—and from that experience, we form a representation of the prototypical category member. Then, when we encounter a new fish, we match it up with the prototype of fish that we have formed in order to decide whether the thing we're looking at is a fish.

- These accounts turn out not to be very helpful, in part because they really don't correspond to how the brain processes information. In addition, categorization is so important for us that we're likely to go about it in different ways.

- More recent theorists believe that there are at least two broad routes to category learning. One is a very deliberate, verbal, rule-based approach. The other approach involves simply guessing about category membership.

- In the rule-based approach, we operate like scientists: We have a guess about the rules for the category, and the rule we're guessing about can be used to make a prediction about whether a new example belongs to the category. Then, we try out our guess, get some feedback, and revise the rules and the guesses for the next round. One example of this approach is learning to differentiate between letters of the alphabet.

- The second route involves making a guess and finding out whether that guess is correct. At some point, we become very good at guessing, but we don't know precisely how we become so good at it.

- Some research suggests that we rely on different routes depending on the kind of category or the nature of the category when learning.

- In some situations, it would be difficult to describe a simple set of rules for making certain judgments accurately without having more experience with the subject area. This type of category is called a nonlinear category, and researchers now think that it is learned by a process of information integration.

- In other words, instead of explicitly testing a rule and keeping your working rule until you find that it doesn't work on a particular occasion and then revising it, people's minds just track the feedback they receive on a more implicit and less conscious level until they can categorize objects well and accurately, even though they're not quite able to tell you how they do so.

Acquiring Scripts

- We acquire scripts in many of the same ways that we acquire categories. There are two ways that we acquire scripts: One is to very deliberately collect information that leads to the rules for a script, and the other is a more tacit approach that involves good guessing after amassing a lot of experience.

- Early in childhood, the process of verbally working through the rules that constitute a script can be seen vividly in a famous case study. Katherine Nelson, a New York–based child development researcher, examined the tape-recorded monologues of a young girl named Emily.

- The recordings were taken between the ages of 21 months and the time that Emily turned about three years old; they were begun very soon after Emily acquired the ability to speak. Each night, after she was put to bed, Emily would lie in her crib and talk to herself. Parent-child dialogue also played a role in these recordings.

- Emily engaged in talk that resembled the kind of explicit rule-based self-talk that we might do to extract a rule about a concept. Not only did Emily focus heavily on the routines of her life, but it's interesting to note that the emphasis on figuring out scripts actually changed over time. Later in her recordings, Emily focused more on unique experiences, and she started to engage in less self-talk about routines.

- This is important because one of the major findings from this area of research is that early in our lives, we seem more attuned to using everyday events to extract scripts rather than trying to actually learn about a specific experience.

- In fact, Emily's monologues are one of the pieces of evidence that suggest an explanation about why we can't recall specific events from very early in our lives. In fact, researchers think that we can't remember specific personal experiences very well until we've actually learned scripts with which we can understand those events.

- This early childhood acquisition of scripts has actually helped to explain a phenomenon termed early childhood or infantile amnesia, which refers to the fact that virtually all adults can't recall specific life experiences from prior to about age three or four years. This is puzzling because many researchers have shown that babies have fully functioning memory abilities.

- The consensus is that those early experiences are not recalled as singular events; rather, what we're really trying to learn from events that occur prior to age three or four is how things usually go. As such, we focus on the pieces of our experiences that get repeated across time. We don't focus on the distinguishing features that make a particular event unique. Until we have scripts, it's difficult to learn from events in general.

- Emily's recordings also showed that we sometimes learn, or try to learn, scripts from a single event. Given that scripts are complicated and multidimensional—in ways that aren't easily described by rules—you might expect that we only learn scripts through repetition. Therefore, one question is how we pull this learning from a single experience off and whether we can do it as adults.

- Researchers Woo-kyoung Ahn, William Brewer, and their colleagues examined this by giving college students some specific stories about Native American potlatch ceremonies, and they assigned students to have different learning experiences.

- The most efficient way for people to learn the script for a potlatch ceremony was to be told the script directly, but people were also able to learn the script from a single story about a specific potlatch ceremony, provided that two things happened: They needed to be given some background knowledge, and they had to use that background knowledge to explain the single story to themselves.

Children who are given a script about the zoo before visiting it learn and remember more than in the reverse scenario.

- An interesting feature of this is students did not spontaneously take the background knowledge and try to explain the event to themselves. They only did it when the experimenters told them to do it. This suggests that we have a large capacity to learn scripts from just a single event, but we probably don't try to do so very often. Perhaps in most cases, we reserve our effort for things that are going to happen repeatedly.

Goals for Learning Scripts

- As children, the data from Emily's recordings and from more controlled studies suggest we're actively engaged in a process of script extraction—that is, we're experiencing events and actively trying to explain those events to ourselves in terms of what we already know about the world, however minimal that might be.

- In childhood and beyond, others are engaged in helping us to do so, too. Emily talked with her parents and her caregivers, and we often talk with one another about the events of our lives to try to figure out what usually happens.

- As adults, the extent of our background knowledge is typically much broader. We've spent a couple decades at least on script extraction, and we're probably less likely to need to develop new scripts. We can therefore remember our daily experiences as distinct events rather than using them to figure out the script for how things usually happen.

- Under some circumstances, we are vitally interested in acquiring new scripts. These circumstances include new jobs, moving to new towns, and taking on new social roles. Depending on the extent of the changes, the old scripts may be useful to us, but the capacity to acquire new scripts is there when we need it.

- Jobs often provide explicit training in the scripts that are important for doing a job well. Other new experiences can leave us with much less explicit training in scripts to draw on. In these cases, the self-explanations and deliberate thought that Emily was relying on may actually be our best adult tools for navigating a new world.

Suggested Reading

Ashby and Maddox, "Human Category Learning."

Nelson, *Narratives from the Crib.*

Questions to Consider

1. In what contexts do people have to learn categories without feedback? In what contexts do they get substantial feedback about whether they are correct? Based on thinking about these examples, does getting feedback speed up category learning? Can feedback have a negative side?

2. Ideas about scripts can also be applied to how we make sense of and perceive more emotionally laden events. Consider how scripts might involve sequences of events such as: "I try something new. It is difficult at first, but then I become able to do it well. Later, it is an important, enriching, and fulfilling part of my life." Or, alternatively, "I try something new. It is difficult at first, and I become frustrated. I give up but later regret that I did not try harder." Are scripts one way to think about personality?

What Babies Know

Lecture 6

So far, we have suggested that we learn for the sake of learning and as we pursue other goals. In addition, we learn by connecting new experiences to what we know already in the form of categories, scripts, and other schemas. Research on early infancy, which makes use of habituation and dishabituation as well as other approaches, tells us that infants are far from a tabula rasa. They come with sophisticated, innate categories and physical scripts that help them make sense of the world.

Habituation versus Dishabituation

- From birth, babies have particular motor reflexes that are so fundamental that their presence is used to indicate whether a baby is healthy. These behaviors are very important for a baby's survival, and they also help tune a baby's motor system by building connections in the neurons in the brain and peripheral nervous system nerves in the limbs.

- An aspect in which we appear to have initial schemata involves physical objects. Six-month-old infants already expect a visually presented object to have three dimensions, to take up space, to fall when it's dropped, and other concepts that we know are true of physical objects in our world.

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The combination of habituation and dishabituation has given us a window into the learning of babies.

- Habituation is defined as decreased responding after a repeated presentation of a stimulus. Early work on habituation looked at whether rats respond to a loud noise by startling and showed that if you repeatedly play the loud noise, eventually rats stop reacting to the noise. In other words, the rats habituated to the loud noise.

- Without habituation, you could never distinguish between the old and the new or the expected and the unusual. Because habituation is a fundamental prerequisite for many more complex forms of learning, it's not surprising that it occurs across all species and is evident even in human beings as young as newborn babies.

- Habituation is not quite as simple as it seems because it involves a decrease in responding over time, and that means we have to consider at least two other explanations before we decide that habituation is about someone's experience with a stimulus and before we can be sure that habituation is a kind of learning.

- In ruling out these alternative explanations, researchers discovered the phenomenon of dishabituation, and it is the combination of habituation and dishabituation that has given us a window into the learning of very young babies.

- Those alternative explanations are that habituation might be caused by sensory or motor fatigue. If fatigue of either sort is an explanation, the only thing that would allow the rat to start responding again is resting the ears or resting the muscles. It's that startling again that we call dishabituation.

- In fact, if you give the rat a break—if you rest the rat's ears and muscles—and then you play the loud noise again, the startling comes back. The rat dishabituates. However, this kind of finding is a problem because dishabituation after a rest is consistent with the notion that the problem is fatigue and that it's not learning.

- The presentation of a new stimulus—a light or a different sound, for example—can cause dishabituation without any rest. In other words, if you play a different tone to the rats and then go back to the original tone, they will startle again. Because there was no rest, this is powerful evidence that habituation is learning—not just fatigue.

- Babies habituate and dishabituate. What this tells us is babies come equipped with a brain that can determine what is old versus new. For researchers, this means that we can also look at what babies know and learn by figuring out whether they habituate and dishabituate to a stimulus.

- We can use habituation logic to test what babies expect and what they don't expect because a habituated infant will look less at something in the environment. Dishabituation in infants is reflected in increased looking time. Therefore, we can interpret the looking behavior of young infants as what they view as old versus new, unexpected, and interesting.

Inborn versus Learned Knowledge
- Renee Baillargeon is one of several infant researchers whose work has revolutionized our view of infants. Baillargeon and her colleagues presented simple demonstrations of movements with physical objects to young babies to show that infants expect objects to be supported in space.

- Other studies show that infants expect that a hidden object stays still while it's covered up. If an object is covered up and then the covering is removed and the object is still there, infants remain habituated. However, if the object is covered up and then when the covering is removed the object is gone, infants respond with dishabituation to the disappearance of the object.

- Infants also appear to expect that nothing can go through a solid object. If they're shown a different object that appears to be moving through a solid object, they stare at it for an extended amount of time, signifying dishabituation.

- These examples imply that the kind of learning that infants do can be built on the inborn assumptions of objects as three-dimensional, solid, and needing support to be off the ground.

- Another arena in which we have interesting inborn capacities— that are also shared with other species—is in our grasp of numbers. The concept of numbers we start out with as infants is not quite the same as the one we learn in childhood when we attend school, and it's not quite the same as the one that later allows us to do complex computations. It's a foundation on which later understanding can be built.

- Babies and animals don't appear to discriminate different numbers of objects in a strict numerical sense. For adults, the difference between one item and two items is the same as the difference between three and four items. In both cases, one pile of items has one more than the other.

- Infants can discriminate between visual displays of a pile of eight dots versus a pile of 16 dots, for example, and as they get older, they're able to make finer discriminations. They can begin to tell the difference between 12 dots and 16 dots, and they share with adults and animals some of the features of how they make those discriminations.

- The critical point to understand is that even newborn infants have some working assumptions and capacities that are based on an evolutionary heritage, and they can bring these working assumptions to the new world in which they find themselves.

Imitation and Cooperation
- Much of what infants come equipped with appears to be shared with other species, specifically the evolved heritage of land-dwelling mammals on Earth. However, the desire and capacity to share understandings with other human beings and to engage in cooperative actions are especially developed in human beings.

- One example of this is that infants appear to have the capacity to imitate other people from virtually hours after birth. Researchers in this area have argued that what this means is that infants are born with the assumption that other people are like them and that imitating someone is an early way of taking somebody else's perspective. It's also the case that imitation is one of the major ways that human babies and children learn about the world.

- More recent evidence about young infants' abilities to take perspective and focus on shared understandings with others has been carried out by Michael Tomasello and his colleagues. They have concluded that even very young human infants try to influence the mental states of other people and that these attempts are pro-social. Infants often try to help other people, even when there isn't going to be any benefit for them.

- Furthermore, some studies look at whether young children communicate only to get what they want as opposed to whether they care that they're being understood. Researchers in this area have found that young children care rather intensely about being understood, even when they're already getting what they want.

- In fact, by 18 months, children already show evidence that they care as much about being understood as about receiving desired objects. Children this young also showed that they could wait to get what they wanted, as long as they were confident the experimenter had understood what they wanted.

- In a series of studies, Tomasello has shown that as soon as they're capable of it, infants will help adults by picking up dropped objects along with other actions aimed at helping. As it turns out, young chimpanzees also do things like this.

- Young children share food with other humans pretty readily, and when they share, they actually share the good food. According to Tomasello, chimpanzees are not the same. In some studies, chimpanzees are uninterested in another chimps' benefits when deciding whether the other chimp should receive food. However, human children respond to collective benefit.

- Humans communicate constantly; they share information. When chimps share information with other chimps, it's largely to get the chimp to do something desirable, such as share their food.

- Furthermore, studies of language-trained apes suggest that they use their language abilities mostly to get the people that they are surrounded by to deliver food, attention, walks, or other rewards.

- The human capacity to cooperate with others, which is richly evident in young children, is widely evident in both problem-solving activities and in games. Chimpanzees cooperate with a human adult, and they do so fairly readily to solve a problem—but not during games.

- In addition to the reflexes and sophisticated knowledge about objects, infants come with an innate capacity and desire to cooperate with other people and to imitate others. These capacities lay the foundations for allowing us to use imitation of others as a learning strategy and for predisposing us to be able to collaborate in learning about our worlds and achieving our purposes.

The Critical Period of Development
- The idea that infants may need to have certain types of experiences in order to retain and further develop initial knowledge structures is the notion of critical periods in development, which suggests that the presence or absence of some experience at a specific time in our lives has a dramatic influence on later development.

- Critical periods in perception are periods in infancy in which the absence of the right types of experiences cause a failure in important developments of the brain, and the results involve lasting limitations on perception and, by extension, learning.

- Humans process faces less well if, during infancy, they had congenital cataracts, which impair vision during an early critical period for development. Infants who had congenital cataracts but had them removed later in life go on to successfully function like normal adults with a few exceptions: They have deficits in the ability to differentiate among faces based on small differences in the spacing of facial features and difficulties in judging depth due to the discrepancy between the images that strike the two eyes.

Suggested Reading

Baillargeon, "How Do Infants Learn about the Physical World?"

Pinker, *The Blank Slate.*

Questions to Consider

1. There are limits to how young an infant can be tested using habituation paradigms. Is it possible to explain the kinds of concepts of objects infants seem to have with early experience and learning rather than with innate knowledge? How does evidence from other species support the innateness idea?

2. If researchers could figure out the right way to expose adults to perceptual input, could we discover ways to help fix the deficits associated with people who had congenital cataracts?

Learning Your Native Tongue
Lecture 7

A s we move into discussing specific types of learning, we'll begin by considering how babies acquire a first language. One of the most profound achievements of learning and development in human infancy is the acquisition of a native language. This achievement, which combines learning and development in interesting ways, is fundamental to our ability to cooperate and communicate with one another, and it's also an achievement of learning that raises issues about a critical period. People who learn a second language after early childhood know how different and difficult that can seem.

First-Language Learning
- At birth, babies don't have the vocal capacity to generate most human sounds. By age two, they are capable of understanding and communicating using a rather large selection of words and phrases. By age five, they can tell simple stories, and by adolescence, they can tell their parents many complex things. All of this learning appears to just unfold, as though there were a program in the brain.

- Learning your first language is, in fact, learning. In addition, first-language learning relies on some innate assumptions and capacities that infants and children bring to that task. Furthermore, the consequences of that first language may be greater than you think because those consequences include the fact that learning your native tongue also means you are losing some capabilities along the way.

Early Language Acquisition Theories
- Initial ideas about language acquisition were grounded in behaviorist theories about learning. The idea was that we learn to speak through rewards and punishments, but that doesn't explain much about language.

- A concept called universal grammar, which was proposed by Noam Chomsky, has been at the heart of most of the work on language acquisition by infants in the past decades. The basic idea behind universal grammar is that babies are born with an implicit knowledge of some deep and basic principles of language.

- According to the idea of universal grammar, children tune this basic structure to the specifics of their own language in early childhood, but they aren't truly learning; rather, they're tuning an already-present, full-blown language capacity.

- The problem with the idea of universal grammar is that studies of human languages are making it increasingly difficult to keep around this idea that there are fundamental, universal properties of all known languages.

- In fact, recent work suggests there's no real universal grammar; there's just too much variability in human languages. Rather, there are some general learning mechanisms that are present at birth, and those permit babies to take all of the language to which they are exposed and to make out of it a native tongue.

Learning Words
- If you plotted a graph of vocabulary development over early childhood, you'd see a slow start in infancy followed by a huge spurt into toddlerhood—a spurt that involves learning more than a word a day and that continues into adulthood. The rate is amazing.

- Phonology is the sound structure that languages have. The important element for sounds in language is contrast, or phonetic distinction. Even very young infants learn phonemes—the basic sound units of their native language.

- Babies figure out how words sound in their native language by listening to speech around them and then figuring out some basic rules for deciding where words start and end. These rules are based on repeated patterns in the speech streams that they hear. From these basic rules, they begin to divide up speech streams into sound units before they know what words mean. Once they have some words, they then use those words and the patterns those words come with to figure out some additional words. This process is often called bootstrapping, which involves working with the little pieces you do know to figure out the things you don't yet know.

Mastering a language requires babies to segment a stream of sounds and pauses into meaningful units.

- Because languages are not random, the probability of certain kinds of transitions of sounds within a word is quite high, and the probability of transitions between words is lower. This is because one word can be followed by many possible words involving many possible sounds, but within a word, one sound has a smaller set of possible following sounds.

- In English, our words tend to stress the first syllable. This regularity helps babies decipher the beginnings of words. Intonation and pitch also help babies distinguish word boundaries.

- When we talk to babies, we tend to use a type of speech that's often called "motherese," which exaggerates word boundaries and other features of our language to make sure that babies can see, hear, and experience those boundaries.

- The central problem for examining the process by which babies learn words is that babies can't talk, and it takes a while before their larynx, tongue, and vocal apparatus even approach adult function. Therefore, how can we know whether a baby knows a word before the baby can speak that word?

- It is unlikely that babies are actively trying to figure out the process of language in the way that adults might; rather, their learning of language is incidental to the task of trying to understand what's happening around them.

- It is interesting that the capacity to extract words from speech streams is preserved in adults. Work by Jennifer Saffran and her colleagues showed that the innate ability to track transition probabilities in sounds combined with exposure to one's own native language makes it possible for babies to figure out words from very early in their lives.

- By high school, adolescents know 30,000–50,000 words. Once children begin to acquire and produce words, their vocabulary size explodes. Children acquire new words so quickly by building a basis of words from phonetic bootstrapping, and then it becomes easier for them to acquire additional words.

- However, young children's word acquisition is so fast—sometimes involving only a single exposure to a word—that other explanations are needed. As with phonetics rules, these often consist of biases in interpreting new words and, in particular, biases that reduce the number of possible meanings that the word could have.

- Some biases are social; for example, infants use gesture and eye gaze from speakers to help decode what a word is referring to. Another bias is not social, but it involves the assumption that new words refer to whole objects instead of parts of objects.

- A further assumption that children may use is referred to as mutual exclusivity, which is the assumption that objects have one label only—so if a known object is given a new label, the new label must refer to some part of the object. Constraints such as mutual exclusivity, along with capitalizing on social understanding, allow children to acquire words very rapidly over childhood.

- There are differences among children in the process of language acquisition that are related to how much parent-child language interaction there is. Children learn more words in speech-heavy, high-vocabulary households than in households that are more taciturn or that use smaller vocabularies. In later childhood and adulthood, vocabulary acquisition is also related to reading habits.

- A lexicon is a collection of words, or a vocabulary. Part of being a native speaker means not only having a lexicon, but also understanding the rules of grammar in ways that let us generate new sentences and understand the differences among sentences that use the same words but in different orders.

Losses of Language Learning

- The process of word acquisition is believed to be largely incidental—that is, babies don't deliberately try to learn a grammar or a new vocabulary—and it's also powerful. A person's vocabulary increases from 0–60,000 in under two decades.

- The contrast with learning a language in later childhood or adulthood is profound. We often experience second-language learning in adulthood as effortful—as requiring intention and deliberate learning of vocabulary—and the end result is usually far short of native fluency and native lexicon size.

- To some extent, this difference is partly due to the losses that learning our first language involves. We often think of learning as a purely gain-oriented experience, but learning changes us, and sometimes the changes involve losses as well as gains. Language is a particularly useful and interesting place to consider these losses.

- At birth, babies have an amazing capability to distinguish between different sounds; in fact, they can distinguish between all the known sounds in human languages, including clicks and unusual phonemes. Unfortunately, this early linguistic brilliance quickly gives way to a more tuned and focused competence.

- In one study, researchers looked at whether young babies and adults who were native English speakers could distinguish between two "t" sounds that are irrelevant to English but that in Hindi mark important word contrasts. Infants between six and eight months of age can hear the difference in these three "t" sounds, including the English "t" sound. Adult English speakers are not able to differentiate.

- Phonetic losses are important because they help tune the brain for the native language. When an infant is potentially growing up bilingual, the brain is tuning for two languages from the beginning.

- Phonetic losses are not all that's lost with first-language acquisition. More conceptual losses also occur, and this is because languages have an important role in marking which conceptual distinctions matter in the worlds we live in.

- After we learn our native language, Elizabeth Spelke and her colleagues have shown that, as with phonemes, we become less sensitive to the differences that our languages treat as less important.

Language and Culture
- Does our first language shape the way we think? One of the most prominent researchers in this area is Lera Boroditsky, who has suggested that some of the most fundamental aspects of human experience involve our experiences of time and space.

- These are crucial categories that affect how we divide the world into past, present, and future and into near versus far. Language is used to represent, think about, and communicate about space and time, and Boroditsky argues that this has some important implications for how we think—and, via an extension of her work, what we can and cannot learn easily.

- In much of Boroditsky's work, she looks at how communities that speak different languages think about space and time. For example, in aboriginal communities in northern Australia, five-year-old children are able to accurately and immediately point north, no matter where they are or whether they can see the sky.

- Boroditsky argues that the reason for this is that this community's language has a very particular, compass-oriented way of talking about relationships in space—rather than using directions such as left, right, in front of, and behind.

- It's probable that this type of absolute orientation might help people learn a new spatial environment more quickly because the model that they're building is less relative to their own position and has more to do with their surroundings than themselves. This may be a more flexible approach to building a model of one's surroundings.

- Just as your native language is an enormous, impressive achievement of learning—learning done almost with no effort at all—your native language is also an arena of tuning your mind to distinctions and concepts that are deemed important by your culture.

Suggested Reading

Boroditsky, "How Language Shapes Thought."

Hansen and Markman, "Children's Use of Mutual Exclusivity."

Swingley, "The Roots of the Early Vocabulary."

1. Relatively little research addresses the development of language pragmatics in early childhood—that is, our knowledge of how language should be used to accomplish our aims in the real world. Imitation alone cannot explain babies' acquisition of syntax. Can imitation explain how we acquire pragmatic rules of language use?

2. Language clearly influences our thinking in many ways. Do you think language is required for thinking? Why or why not?

Learning a Second Language
Lecture 8

I n the last lecture, we talked about the amazing and effortless way in which infants acquire a first language. Learning a second language, though, feels anything but effortless. In this lecture, we're going to look at whether and how other species have been able to learn human language systems—or systems very like human language. In addition, we'll look at how the experience of human adults learning a second language is both like and unlike the case of babies learning a first language and how it is like and unlike animals learning an alien way of communicating.

The Language of Primates

- Some of the ways human beings learn languages have to do with general abilities to monitor statistical relations in perceptual experiences: the ability to track which sounds go together often and which sounds almost never go together, for example. We share these abilities with other species.

- We share much of our genetic heritage with primates, but human speech requires special properties of the vocal tract that most other species don't share. Therefore, we are talking about the ability for primates to acquire symbol systems, such as sign languages or other artificial systems for communication.

- Apes that use these systems have been trained in one of two ways. In one way, animals are trained using rewards—operant conditioning— to link symbols, such as signs or pictograms, with objects. With this approach, training begins relatively late in the ape's childhood and occurs exclusively between the ape and other human beings.

- In the second way, animals are exposed to symbolic communication early in their lives and learn alongside their mother, for example. In this case, apes appear to have more sophisticated skills and to use the symbols with each other as well as with other humans.

- With extensive training, apes acquire up to 500 distinct symbols, but they don't have the kind of takeoff that happens for younger children, and acquisition is certainly not effortless. Instead, it requires fairly intense training efforts from human caregivers.

- Grammar and syntax seem to be absent in animals that have been trained with symbol systems. It's rare for them to combine more than two symbols, and the combinations they make are simple and constrained.

- Some studies show that more than 90 percent of the communication that trained apes engage in with their human caregivers is in the form of imperatives—that is, once animals acquire speech-like capacity, they use that capacity to get what they want.

- In fact, although there is some significant disagreement about the nature of animals' achievements in language, researchers have observed that humans use language to represent their thoughts and to communicate about those thoughts, while apes largely use language to communicate their desires.

The Language of Parrots
- Language studies with animals have not been done only with apes. In fact, parrots can be taught to speak. Alex the Parrot was taught to speak by a researcher named Irene Pepperberg, who used a very interesting technique that is different than the techniques used with primates.

- In this approach, while Alex watches, two human beings interact around an object that Alex has already shown some interest in or some curiosity about. One human might ask questions about the object, and the other human responds to the questions. The human is praised when he or she gives a correct answer and receives disapproval when he or she gives an incorrect response.

- In this case, disapproval involves scolding, removing the item from view, or asking the human to try again. With Pepperberg's method, the correct word is rewarded with the object itself, so the parrots can use language to get what they want in a more direct way, as is the case with human children. With primates, rewards, such as bananas, are often not the objects that are being discussed, which results in confusion.

- Alex the Parrot can make requests, label 50 different objects, and identify shapes, colors, and quantities. However, Alex doesn't use language like human children do. Although his experiences were in some respects more like those of human children, they were still more intensively focused on training language using principles of operant conditioning.

- These methods are somewhat analogous to the methods that we sometimes use to acquire a second language later in our childhoods or as adults. In addition, they're more disappointing in their outcomes, which to some extent may also be true for our efforts to learn second languages.

Human Adult Second-Language Learners

- Even animals appear to be better off if their language training starts very early in their lives. Is there something unique about language acquisition and babies? Is there a critical period for learning language, and is that why learning a second language as an adult is so much more difficult than learning a first?

- Along with evidence from case studies of children reared without language exposure, whose adult attainment of language is never quite normal, research suggests that if you don't get early exposure to a second language, you can never achieve native-like capabilities in speaking or using that language. There is a biological constraint on learning a second language.

- It is possible for adult onset learners to obtain virtually native competence, but for the most part, researchers acknowledge that second-language acquisition for adults is difficult, and it produces a lot of variability among people. On average, second-language acquisition has poor outcomes.

- Many languages mark nouns by gender so that there are male nouns, female nouns, and sometimes even neutral nouns. English doesn't do this, so it may be difficult to reacquire this conceptual category system if you did not develop it in infancy and early childhood. In addition, we use stress and intonation patterns to decode speech that are not the same from language to language.

- Attempts to train people to recognize phonemes—the smallest sound units in a language—that they don't need to distinguish in their native language have not been successful, although this is an area of active research today.

- The incidental learning of words that we seemed able to do as children doesn't always happen with second languages; it appears that sometimes we need to be more intentional in order to acquire new vocabulary.

- Learning a second language is a goal for many adults and others beyond early childhood—despite all the negative information about language learning. There are obvious reasons why it's useful to be able to speak other languages, including giving us benefits during later life by protecting us from cognitive declines that occur in aging.

- Many general learning principles apply to learning languages, such as engaging with the material deeply and using elaborative encoding, which means linking new material to what we already know to enhance our ability to learn and remember the new information.

Tips for Learning a Second Language

- An important technique for learning a second language is immersion, or being immersed in a language. One major predictor of second-language learning outcomes—of how well people learn that second language—involves learning in the second-language country versus in the home country.

- Research suggests that people are equally accurate at grammar when they learned in their home country and when they learned in the second-language country. However, learning in the second-language country appears to improve your lexicon, vocabulary, and grasp of the pragmatics of a second language, which include politeness phrases, slang, and other kinds of nuances of how a language gets used.

- Immersion is better than learning in your home country. First, sheer exposure to language is much greater if you're immersed in the country where you're trying to learn the language than if you're at home taking classes. In addition, in a foreign country, the language is critical for living, and this can make acquisition feel quicker and more efficient than learning in the classroom.

- In addition to immersion, you want to choose the language you're going to learn carefully. The issue is not in the specific language, but rather it's in the distance between your native language and the one you're trying to learn. Studies suggest that the greater that distance between your native tongue and your second language, the slower you are to learn the second language, the harder it is to acquire it, and the worse you will do at the same point compared to those learning languages closer to their own.

- In addition, differences between people in how well they learn a second language aren't just a function of who gets immersion and who spends more time and effort. There are real individual differences in language learning capacity, and studies of twins suggest this ability is highly heritable.

When in a foreign country, learning the language often feels more purposeful and efficient than learning in a classroom.

Being Truly Bilingual

- In the continuum of language learning—from babies (effortless and perfect) to other species (highly effortful and poor outcomes)—second-language learning by adult humans is somewhere in the middle. Unlike other species, we can, given the right situation and good luck on genetically based aspects of ability and hard work, approach perfection.

- However, like other species, we may not be able to learn in quite the same way as we once did. We may need more explicit, deliberate learning strategies, and there are some limits to how perfectly we can learn based on our native language.

- The exception to this rule is learning a second language during the critical period in early childhood. In that case, people have a chance to be truly bilingual—proficient in two languages.

- The issue of being bilingual raises a common concern about language learning: that if we learn two languages, we'll somehow be behind in both or be adversely affected in one of our languages by virtue of learning the second. There is no reason to worry about this for children, and there's every reason to encourage bilingual experience in childhood.

- However, operating in two languages involves the ability to inhibit competing responses. If you want to use one language, you need to be able to push away the vocabulary and words of the other language. The more languages you try to learn, the more potential competing responses you have—and the more experience and more possibilities to link prior knowledge to new vocabulary and grammar you have.

- Research suggests that the capacity to inhibit responses in general gets strengthened when we consistently have to operate in more than one language, and improved inhibition can help our learning much more broadly in many other areas.

- Learning a second language is effortful, and it's difficult in part because of the way in which a brain tuned to our native language misses important information in the new language, making it difficult to acquire particular sounds, concepts, and grammatical structures in that new language. This difficulty means that in second-language learning, we have to employ more deliberate and effortful strategies to achieve mastery of that language.

- However, we're far from being as badly off as nonhuman species in learning a new language, and the ceiling on our second-language acquisition—while perhaps lower than the ceiling for our first language—is still pretty high.

Suggested Reading

Hyltenstam and Abrahamsson, "Maturational Constraints in SLA."

Savage-Rumbaugh, Segerdahl, and Fields, "Individual Differences in Language Competencies in Apes."

Questions to Consider

1. To what extent do adult learners of a second language face similar or different learning problems as nonhuman animals?

2. In what ways can immersion-like experiences be created in one's own country?

Learning How to Move
Lecture 9

V irtually all learning combines skills and knowledge, but as we move through the next section of the course, we're going to move from an initial focus on skill acquisition to a focus on knowledge. Furthermore, we will consider both tacit forms of learning and more deliberate forms of learning. In this lecture, we will look at motor learning— or learning how to move in ways that allow us to achieve particular goals— and how it is acquired. In addition, we will consider some important issues for maximizing motor learning, including verbalization, observation, and visualization.

Feedback Systems

- Our days are full of movements large and small, and we take many of the movements we make for granted; in fact, it may not seem like we ever learned some motor skills at all.

- Of course, there are many motor skills that we may vividly remember acquiring—or, perhaps, not acquiring all too well. For example, you might remember learning how to play tennis or to dance.

- As with many types of learning, we need to perform the behavior we're trying to acquire repeatedly with motor learning. The more practice and repetition you experience with a movement, the better your ability to make that movement will be. Furthermore, the more that practice is distributed over longer periods with rest intervals in between, the better your retention of the motor skill will be over time.

- Similarly, there is no tabula rasa with motor movement. In fact, when a baby, animal, or adult human try to learn a new movement, they are usually assembling bits and pieces of movements that they already know how to do.

- In acquiring new motor skills, under most circumstances, we also critically need feedback; we can't just rely on repeated exposures and repetitions of the movement itself without any sense of whether we are doing the movement correctly.

- There are two types of feedback, and they vary depending on where we are in the learning process. One source of feedback is called knowledge of results. For example, consider target shooting or typing; it is very clear and obvious whether the movements you make result in success.

- When babies begin to learn to reach and grasp objects, they make use of knowledge of results to refine and hone their movements. The same is true for standing, walking, and other motor skills that we acquire early in life.

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With dance and other performance arts, knowledge of results as a source of feedback is not always clear to the beginner.

- Not all skills entail obvious knowledge of results. With dance and other kinds of performances, knowledge of results may be less available; it is not always clear to the beginner whether the body has executed a movement correctly. For many kinds of motor skills, it is important to get feedback from others in the initial stages of acquiring those skills.

- Feedback sources also shift across time as people develop more capacity within a given area. As skill improves, people begin to rely more on a second feedback system: the proprioceptive system.

- The proprioceptive system is one of our senses, but it is one we usually ignore unless it malfunctions. It is the system of sensory inputs and sensory processing that tells us where we are, how we're positioned, and even the relative tension or the lack of tension in our muscles.

- Like any of our sensory systems, the proprioceptive system consists of receptors and nerve projections that carry the receptor signals to the brain. Once at the brain, those signals can be interpreted and made use of to help us do whatever motor action we're performing at the time.

- The proprioceptive system involves parts of the inner ear called the vestibular apparatus, receptors called muscle spindles that are located in what is called the belly of our major muscles, and additional receptors in joints and in the junction between tendons and muscles.

- These different receptors take in distinct pieces of information. The vestibular system involves receptors that signal posture, balance, and head movements in relation to gravity. Muscle spindles add different information into the proprioceptive system—such as how tense your muscles are and how quickly they are contracting—and they also help to tell you how your joints are positioned.

- All of these receptors transmit information to the brain, which then integrates all that information so that we have an awareness of where we are, how we're standing, and how we're moving with respect to the world around us. These signals also provide feedback about our performance of motor movement, and it is feedback about the process of making the movement that can help us acquire a motor skill.

Stages of Motor Learning
- Our initial experiences of learning motor movements are often verbal and fairly cognitive. Gains at this stage are very rapid and large—after all, people are starting from almost no skill—but people's movements in this stage are not very smooth, effective, or reliably produced.

- In fact, at this stage of motor learning, there is a lot of variation in how effectively people can produce a movement, and this is the place where feedback in the form of knowledge of results is salient and important. In this stage, we're learning a lot about our motor movement by using visual input and knowledge of results as feedback.

- Next, learning a motor movement goes toward refining and automating a motor movement pattern so that we can do that pattern without deliberate thought. At this point, things begin to vary depending on the kind of motor skill that we're learning.

- Dance moves are considered closed skills because the environment for performing those skills is pretty predictable: You know how the stage will be and how you need to move on that stage, and the idea is to move in the same way each time for a particular dance. The key to motor learning in these cases is to learn the best, most effective movement and to be able to reproduce that movement reliably.

- Many motor skills—such as tennis, driving, and typing—are considered open skills because some basic motor movements may be involved, but you also have to change the movements in response to changing environmental conditions.

- For open skills, the refinement process takes significantly longer, and people also need to make very certain that they practice the motor movements in different conditions because that's the only way they will be able to respond to changing environmental conditions. In fact, if people train under too homogenous a situation, the generalizing of the training to real performance conditions is not going to be very good.

- After this middle stage, people move to what's called by some researchers an autonomous phase of motor development, which is characterized by continued learning—even long after we think we're not improving anymore.

- Improvements at this stage are difficult for people to detect because they are already performing very well, so the amount of improvement is very small in comparison to what they have learned so far. In addition, the learning is not happening at a level where people are attentive to it, and in fact, people may not even notice that their movements are becoming more refined.

- At this phase of learning, almost all of the feedback that's relevant to honing motor skills is proprioceptive feedback within the body and outside our conscious awareness.

Improving Motor Learning
- If learning a motor skill initially is verbal and cognitive, verbalization can be used to help people acquire a motor skill in the first place. An example of an instructor using verbalization to help people learn motor skills is when an artist teaches others to paint by verbalizing brush strokes that achieve a particular technique.

- Verbalizing during early acquisition, as we're just learning a movement, appears to be helpful. Later in the learning process, verbalizing may actually disrupt our motor skills.

- Verbal instructions can be very useful because they direct participants' attention in the right way. The verbalization focuses attention on the movement to be learned at a phase where we can't produce that movement automatically. Where and how we focus our attention during motor learning also turns out to matter a great deal.

- In this arena, an external focus of attention generally means a focus outside the body and self—often, a focus on the goal of the movement. An internal focus means a focus on the self, on one's own thoughts and feelings or movements. An external focus is often a better focus for motor learning than an internal one.

- Gabriele Wulf and her collaborators have analyzed people acquiring a broad variety of sports-related motor skills. While they're learning, some people in these studies are asked to focus internally on the bodily experience of the movement, and others are asked to focus externally on the ball, for example, and its trajectory.

- In Wulf's studies, an external focus improves the speed with which people acquire a motor skill, and it improves their level of performance with that skill. An external focus helps because as we acquire motor skills, our shift from jerky, uncertain movements to smooth, automatic movements happens via feedback loops that involve comparing what we actually accomplished with our movement and what we had wanted to accomplish.

- The feedback loops involved, though, exist at both conscious and nonconscious levels. At a nonconscious level, your proprioceptive system and visual system are interacting with one another, and they're adjusting your movement without your deliberate thinking process.

- Deliberate thinking is effortful, slow, and inefficient compared to the kinds of mental processes we have that are more nonconscious and automated. Therefore, an internal focus when we're learning motor skills can interfere with the more automatic feedback loop that involves proprioception and vision, and it can shift us to the more effortful process of deliberate thought instead.

- As compared with some other types of learning, the distinction between explicit and deliberate processing is very important with motor skill learning.

Observation and Visualization
- When we learn a new motor skill, we often begin by observing others. Physical practice is better than just watching, but research has shown that it is extremely helpful to watch someone engage in a motor skill, practice what that person did, and perhaps talk about strategies in between.

- Although observation is clearly helpful for motor learning, it can be more helpful for some people than for others, and the key difference is in expertise. Depending on the motor skill to be learned, observation may function more effectively for people who already have a little bit of experience with a task.

- Visualizing success in motor tasks is not only highly motivating, but it also might be effective at helping people acquire a skill.

- Imagery is defined as the process of mentally rehearsing a motor act without moving the body. Imagining motor actions involves the same brain regions as doing the motor movements. In addition, imagining motor movements takes about as much time as doing the motor movements, and it can even create the same changes in breathing and heart rate.

- Imagery can help in the acquisition of motor skills in two ways: It can help you gain more with less physical practice, and it can sometimes result in better outcomes.

Suggested Reading

Schmidt and Wrisberg, *Motor Learning and Performance*.

Questions to Consider

1. Are there individual differences in the ability to use observation to learn motor skills? Think about yourself and people you know.

2. If visualizing successful movements facilitates motor learning, what about visualizing failures? Could visualization facilitate other types of learning as well?

Learning Our Way Around
Lecture 10

From very early infancy, we are equipped for learning about space and objects within it. As we get older, learning our way around happens first through navigation and eventually through the use of maps and other representations. These distinct ways of representing space have implications for what we learn, but in general, we're trying to build a cognitive map over time that allows us to represent space flexibly and with enough—though not necessarily precise—accuracy. Although navigation often involves conscious work, the spatial learning that arises from it is often relatively tacit.

Spatial Learning

- Spatial learning involves some aspects of skill but also some aspects of knowledge—representations of how the world is organized in space. Spatial learning problems are problems we share with all mobile creatures on the planet, most of which do some type of foraging or hunting activity to obtain food and water. Many mobile creatures—as varied as squirrels, birds, and human beings—store and must later retrieve food or other necessities from various locations in their environment.

- Spatial learning allows us to accomplish several important tasks, including orienting, which involves knowing where we are and where desired objects or places are in relation to our current position. In addition, we can navigate using spatial learning by integrating sensory and perceptual feedback into our orientation knowledge on a continuously updated basis.

- Many species have impressive capabilities for using sensory and perceptual information about the position of the Sun or Earth's magnetic pull to orient in truly amazing ways during long migrations across Earth.

- For example, homing pigeons can fly directly home after being placed several hundred kilometers away in unfamiliar territory. In addition, honeybees can use magnetic fields to orient and navigate, making their ability to forage and return to their birth hive incredible.

- There are also distinct navigational tasks that vary in their demands, and two of those that matter to human beings are piloting and path integration. Piloting is finding a goal by familiar reference points, so it is a very typical navigational task for most animals and humans. This is the major task in getting to and from work and school.

- With path integration, you might wander around widely. Path integration happens for human beings on a daily basis when, for example, you run a bunch of errands and then return home via the most direct path to your house.

- Human beings can't read magnetic fields, but our spatial abilities are quite good. In fact, what we have in common with honeybees and other species is that we learn cognitive maps of our spaces. A cognitive map is a representation of a new space that will allow you to accomplish many different actions within the new location and to flexibly navigate that space.

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Our ability to build cognitive maps of spaces we observe is present very early in life.

- A good cognitive map shows us where we are, where important objects or landmarks are, and which possible paths we can travel to move around from one point to another within our space.

- For most humans in the modern world, there are a number of ways we encounter spatial information. Perhaps the most primary way is through direct perceptual experience.

- Perceptual experiences are both static—such as when you stand still and look at the array of items in a space—and dynamic— such as when you move around and through a new environment, learning what routes there are and what kinds of objects are within that environment.

- Our ability to make use of static visual perception, to build maps of spaces we're observing, is present very early in life. Research suggests that by three to four months of age, infants are already distinguishing between different areas of a spatial array that they look at. Spatial abilities are almost certainly part of our evolutionary heritage.

- As we get older, we can experience the spatial world in more ways by moving through the world so that we get some dynamic visual experience and by using abstract representations such as maps or verbal descriptions of a space.

Allocentric versus Egocentric Perspectives
- Allocentric perspectives of space are perspectives that are not necessarily specific to your own position within a space. A typical way to represent an allocentric view is to think about a map or to consider a mental model of a space, such as a floor plan of a house.

- One advantage of this perspective is that you can move it around and rotate it in different ways. Another is that you can consider how spaces within the house are related to one another more easily. An allocentric representation of a space does not change when you move to a different vantage point; it is helpful for path integration.

- Egocentric perspectives of space are perspectives that have to do with where you are standing and how you are moving. These are sometimes called route perspectives.

- In an egocentric perspective, what you represent of your house is the experience you have of walking or moving through the house. Egocentric perspectives are less flexible than allocentric ones, but they are one of the central ways that we experience spaces that we're in and arrays of objects that we move through.

- One of the important issues in spatial learning is how we move from what is in an egocentric perspective in our everyday experience to an allocentric one over time and with increased experience.

- There are some specific cases where egocentric perspectives are actually better than allocentric ones, including route knowledge. In addition, egocentric perspectives may be maximally useful for piloting.

- Research suggests that as people experience an environment through navigation, they increasingly build a more allocentric representation, beginning with landmarks that help them to orient, then connecting landmarks with routes, and finally integrating various routes to arrive at something more maplike.

- It is important to note that our cognitive maps are not veridical— that is, they are not precisely accurate in representing the world that we live in. Instead, they're cognitive approximations.

- We do much of our spatial learning without devoting exclusive attention to that process—that is, we pay attention to the immediate problem of getting from point A to point B. Over time, we make use of the experiences of getting from point A to point B and also to points C, D, E, and F. We make use of these experiences of getting around to build a more allocentric cognitive map.

- We often vary in our spatial learning goals. Sometimes we just want to learn the best route from point A to point B, and other times we really want to understand where we are and how different areas are located with respect to one another—other times, we really do want to have a map.

- Adults often use maps to learn more information about areas in addition to navigation, so to learn about these issues with adults requires us to look at how they use map-related information in learning in addition to using maps for navigation.

- If you're engaged in learning a new area, maps serve one set of needs. For example, if you want to get a sense of the layout of the entire space and how places in that space are related to each other. Navigation serves a different set of needs, such as getting from one point to another. Over time, navigation contributes to the building of an allocentric model, a more maplike model.

- This is probably because allocentric models are more effective for being able to navigate flexibly from any point to any other point. That is, for a specific navigation task, you may not need the layout of the entire space, but when you want to have options, the layout—the allocentric model—is a critical thing to have.

Spatial Learning and Gender
- Stereotypes about spatial functioning and gender abound, and there are a number of studies that show that men outperform women at spatial learning. Moreover, these gender differences are evident across multiple studies and even across multiple species.

- However, not all research supports the existence of a general male spatial advantage; it may depend on what the task is. Pierre Lavenex and Pamela Banta Lavenex suggest that we need to think about several things before we conclude that women are poorer at navigation and spatial learning than men.

- They suggest that we need to make sure we don't confuse spatial learning with other tasks that involve spatial abilities but aren't necessarily critical for developing a cognitive map. For example, rotating objects mentally is a common spatial ability task—and it's one in which men show a very strong advantage—but it's not critical for spatial navigation.

- In addition, they suggest that women typically show distinctive strategies for exploring an environment, even when they perform similarly well. Women are more likely to explore an environment extensively, which might result in poorer performance—depending on what counts as good performance.

- If you take a longer-term perspective, then getting lost has some longer-term value in terms of building a more complex and thorough map. This is true for both genders, even if one gender gets lost a bit more than the other.

Spatial Learning and Designing Spaces
- Planned complexity for a building has several features. One feature that makes buildings more or less complicated is the number of choice points, or hallway intersections. The more choice points you have, the more complicated the building is to learn. Another feature is how many signs there are and how visible they are.

- A broader array of issues affect learning to navigate a building, including visual access—how well you can see one part of the building from another—and architectural differentiation, which is how distinctive the different areas of the building are from one another.

- Research on the complexity of different buildings, which is determined by analyzing planned complexity, shows that buildings higher in complexity cause problems for people in navigating and make it take longer for people who work in those building to acquire a good allocentric map of the building.

- For buildings that are designed primarily for use by insiders, high planned complexity is fine because there is no need for a stranger to walk in and be able to navigate the building immediately with speed or accuracy. In other buildings—such as libraries, hospitals, and hotels—lower planned complexity is needed.

- Buildings requiring low planned complexity should be organized along one central axis, which makes them simpler to understand and reduces the number of choice points. In addition, these buildings need to maintain visual access. Finally, these buildings need to keep different areas distinct in color and form to help people figure out quickly where they are.

- In addition to properties of buildings, some of the problem is in human beings in general, but other aspects of the problem are specific to individuals. People bring assumptions when constructing a cognitive map, and they also tend to simplify and, therefore, distort their cognitive maps. In addition, some people are simply not good at navigation while others are, and researchers are only beginning to understand why that might be and what it means.

Suggested Reading

Allen, ed, *Human Spatial Memory.*

Carlson, Hoelscher, Shipley, and Dalton, "Getting Lost in Buildings."

Taylor, Naylor, and Chechile, "Goal-Specific Influences."

Questions to Consider

1. Given the research findings reported in this lecture, how might one best give directions to a stranger to an area? What about to a person familiar with the city?

2. How do you think the increasing prevalence of GPS and other technological solutions for navigation might influence our spatial learning in the future?

Learning to Tell Stories
Lecture 11

S torytelling is an area of learning that is acquired in the service of other activities with repeated practice and assistance from adults and others. In this way, learning to tell stories is similar to learning our way around a new town. The stories we learn to tell reinforce our membership in such groups as our family, subculture, economic class, and larger culture. We start out learning to tell stories, and then we use storytelling as a way to learn, which brings us to a shift from learning a skill—telling stories—to learning knowledge.

The Importance of Storytelling

- Storytelling is a crucial way that we connect with other people. It is also an important learning mechanism for learning about ourselves and about the social world across our lifespan. It's also an important way that we teach other people.

- People first learn to tell stories and then they're able to learn from stories, and through storytelling, we can represent experiences that are displaced in time and space. Unlike other species, we can talk about what happened there and then, and we can make it part of our here and now.

- The flexibility we have in being able to talk about there and then allows us to keep drawing on past experience to make sense of the present. In this way, stories are a fundamental mechanism for learning—they're a fundamental way that we can engage in elaborative encoding.

- Learning to tell stories is an important way in which we become members of our culture because part of learning to tell stories is learning to tell them in the culturally appropriate way, which varies from place to place.

- What all of us learn through storytelling is to narrate our own experiences in a way that is ordered in time, communicate the essential details of what happened in those experiences, and make it clear enough to our audience why they should listen.

- The experiences we have are rich in sensory and perceptual details, so to translate that effectively into a verbal form isn't an easy task. Storytelling also requires adaptation to the audience—to what the audience does or does not know and to what the audience is interested in or not.

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Storytelling helps us to bond with other people; it is also an important learning mechanism.

Features of a Good Story
- A good story has at least four features, and children learn to employ these features across childhood and even into adulthood and middle age. Two of these features were named by Jerome Bruner as the landscape of action and the landscape of consciousness.

- An adequate story has to communicate what happened, which is the landscape of action. However, a story that communicates only what happened isn't sufficient; a good story also conveys the landscape of consciousness—the thoughts, desires, and emotions of the people involved in the event.

- Stories also do two additional things that we have to learn to do: They convey the way events happened in time, and they make an experience coherent, sensible, and meaningful by putting all the action and consciousness elements in order and by presenting them in such a way that the story has a point, or larger meaning.

- We're not born with the capability to tell stories that are good along these four features. From early childhood and into adulthood, our stories become longer and convey more of the landscape of action and consciousness.

- As we get into adulthood and middle age, we continue to sharpen our ability to convey the landscape of consciousness, which changes in its nature over time.

- For young children, the landscape of consciousness is reflected in how the child felt, which emotions were experienced, and what the child wanted. By middle age, we're still talking about how we feel and what we want, but we're also talking about what an event signifies about our values and morals.

- From early childhood into adulthood, we become more sophisticated at conveying the sequence of our experiences and at telling our stories in ways that have more meaning. We even acquire the ability to tell stories with flashbacks and more complex structures.

- These developments in personal storytelling about our own experiences are mirrored by age-related changes in the ability to narrate fictional experiences as well. However, these findings come from studies of age differences in how people tell stories—what they don't reveal is how we learn to tell those stories.

- Particular developmental changes allow us to acquire new storytelling skills, but this process also involves learning.

- The developmental precursors for learning to tell stories in the way that we do as adults include language, memory, and self-awareness. The emergence of language is a critical factor.

- A second developmental factor involves memory function. Basic capacities for memory function are in place by the end of a baby's first year, but memory systems mature up until about age eight, which is when these systems function the way they do in adults.

- A third factor is that learning to tell stories about our experiences also requires a sense of the self that is thought to emerge by about the age of 18 months.

- Once those factors are in place, the major learning process for storytelling is immersion in learning. Just as with motor learning and spatial learning, a major force in learning this task is to just do it.

- In addition, the task involves a relatively implicit way of learning. Children come home and tell a story about their day to share information, seek comfort, or share a laugh. Through the pursuit of those other goals, they simultaneously are learning how to structure a story.

- Early in the process, children need help from adults and older children to build a structure in which they can tell a story. This process is called scaffolding by developmental psychologists.

- For young children learning to tell stories, scaffolding from parents often looks a lot more like parents telling a story around a child's minimal contribution.

- Over time, children's stories develop into elaborated and more sophisticated stories that are more accessible to an uninformed audience. As children get older and show more capability at telling stories, parents pull back and ask their children to put more of themselves into the story.

- Children also learn how to gauge from a listener whether they are paying attention, how to shift their story to get attention, how to recognize that the listener looks confused and provide clarification, and how to note the facts and also include the larger point of a story.

- Parents differ in the ways that they scaffold their children's storytelling, and those differences shape what children learn about how to tell a story.

The Elaboration of Stories

- Some stories are told with rich detail and vivid emotion, and others are told more sparsely or in a more taciturn way. Robyn Fivush, Elaine Reese, and their colleagues have looked at how parents conarrate stories with their children from very early in life. Broadly speaking, they find that there are two kinds of mothers: elaborative and repetitive.

- Elaborative mothers encourage their children to express a broad range of information about the event, including what happened; who was there; why the event occurred; and what the child and others thought, felt, and wanted. By contrast, repetitive mothers emphasize accuracy; they're interested in a few key details but not in a broad, elaborative approach.

- Fivush and Reese have found that by elementary school age, children of elaborative mothers include more detail and vividness, and they talk more about emotions and about meaning than children whose mothers are repetitive.

- Importantly, the act of telling stories is fundamentally an act of learning about our own experiences and history. Therefore, when we tell a story, we are retrieving and re-encoding the experiences of our lives.

- As a result, elaborative children may end up remembering more of their own experiences because their ways of learning those events through telling them were more elaborate. They used deeper encoding strategies to learn about their own lives.

- The way we tell stories about our experiences has lasting effects on how we remember those experiences and what we learned from them. Furthermore, telling yourself a story of what you learned can be an effective reinforcement for learning in many contexts.

- A more close-grained study of elaborative mothers has suggested that they are warm and affectionate, provide encouragement and support to a child as the child attempts to tell a story, and provide clarity and assistance on how to search memory and how to reconstruct an event.

Storytelling and Culture
- Within psychology, Chinese and American cultures are viewed as varying quite a bit in their relative emphasis on individual distinctiveness, which is emphasized more in the United States, versus relationship obligations and duties, which are emphasized more in China.

- Qi Wang and her colleagues looked at mother-child storytelling about the child's experiences in Chinese and American families, and they found that Chinese mothers focused less on lengthy and elaborative rehearsals about the way the event highlighted the child's unique characteristics.

- In addition, they found that Chinese adults had shorter and less detailed personal memories that had themes of duties and relationships when compared with American adults.

- Recent proposals by Dan McAdams have focused on what he views as a characteristically and peculiarly American way of telling stories called redemptive storytelling, in which we talk about how the bad, negative, traumatic, and tragic were made good, somehow, by a more optimistic ending.

- We all belong to multiple cultures and subcultures, and in fact, some findings suggest that the kind of story that works within one part of our lives could be less effective in other contexts.

- Shirley Brice Heath examined language use in low-income European-American and African-American communities as well as in a middle-class white community. She found that low-income African-American children were gifted storytellers. By contrast, the European-American groups seemed to focus on the function of stories to inform, resulting in a push for accuracy.

- The implications for school are potentially problematic: The creative storytelling rewarded in one's community may not be an easy fit with the school's orientation toward accuracy, and the creative talent of the more entertainment-oriented storytelling may be underappreciated in some school settings.

- One of the least understood aspects of learning to tell stories is how we learn to adapt our stories for different social contexts. One of the things we have to learn over time about telling stories is how to successfully craft the story for different audiences and different purposes.

- Many studies show that by the age of three, children know the difference between reminiscing, telling stories together with other people who experienced the event, versus recounting—telling a story to someone who wasn't there and therefore needs more background information and explanation.

- For the children studied, children who are middle class and predominantly white or Asian appear to be more oriented toward recounting—telling to share information rather than for entertaining.

- By adolescence, we know that we should edit versions of stories to not offend parents or other people around us. However, how we learn to use narratives in context-specific ways represents an open question in this area of learning.

Suggested Reading

Brice-Heath, *Ways with Words*.

McAdams, *The Redemptive Self*.

Questions to Consider

1. Elementary teachers often speak of a shift from learning to read in kindergarten and first grade to reading to learn in the later elementary years. Might a similar shift characterize learning and stories—from learning to tell stories to learning from or through telling stories?

2. Stories aren't always true, as entertainment-oriented storytelling shows. If stories are not true, does this undermine the notion that we are learning from them? Are we learning wrong information from stories? Why or why not?

Learning Approaches in Math and Science
Lecture 12

Learning in math and science domains combines a focus on the facts we know about the world with a focus on a process that people can use to identify and solve new problems. Like storytelling, once we learn the skills within these domains, we are able to also use those skills to generate and acquire more knowledge. When learning math and science, it is important to have clear and explanatory feedback and to engage in self-explanations because it is the process of explaining errors to ourselves that can lead to real learning—of new strategies or even new problems.

Learning Strategies in Math and Science

- Strategy acquisition in math has been studied by a variety of researchers, but the work of Robert Siegler and his group stands out. They have focused on a number of types of problems in math. Some of their work looks at how children learn the counting on strategy for solving addition problems, for example.

- Initially, young children use their fingers and counting to solve addition problems, but this doesn't work well when they realize they don't have enough fingers. Eventually, children learn that they can begin counting from the larger of the two numbers in the problem, and that expands their counting options significantly.

- Class-inclusion problems involve reasoning about wholes and parts. As an example, John has three cats and four dogs. Does John have more dogs or more animals? You can solve this by counting—which is an empirical strategy—or by reasoning about sets and subsets—which is a logical strategy.

- Although adults can continue to have trouble with class-inclusion problems of a relatively sophisticated sort, most of us acquire a basic understanding of these problems in early to middle childhood—by the end of the elementary years.

When they begin adding, young children count on their fingers to solve addition problems.

- Microgenetic designs make many observations of people learning something over a short period of time. Generally, such studies show that right before people discover a new strategy or approach to a problem, their performance becomes more variable.

- The discovery of a new strategy is followed with a period in which the new strategy coexists with older ones, even when children know the advantages of the new strategy. Adoption of new strategies is slow.

- Variability across different children is high. In addition, solving class-inclusion problems is something we learn to do; it doesn't require special maturation that only happens magically by a certain age.

- Class-inclusion problems can be learned quickly, given a few conditions: many opportunities to try out the problems, feedback about whether we are right or wrong along with an explanation about why our wrong answers are wrong—specifically, an explanation that highlights the correct, and most efficient, solution strategy.

Self-Explanation Research

- In her work on science learning, Michelene Chi and her collaborators have noted that self-explanations play a critical role in determining how well people learn aspects of physics and other sciences.

- A feature of science is the role played by models of how things work; to understand many aspects of science is to understand something about the model that is supported by existing data.

- Chi's work focuses on how people learn and update their models of how something works—with a few key assumptions. First, Chi and her colleagues assume that everyone brings an existing understanding, for example, of electricity—although it may be flawed.

- For Chi, science learning is a process of changing an existing model to a more accurate one based on readings or other experiences that expose students to facts. Chi and her collaborators focus on self-explanations as a key factor that can improve this process.

- They define self-explanations as the occasions of talking yourself through a difficult problem or text in which you explain what you do know, try to think of related knowledge, and try to identify what you don't know.

- This process is similar to elaborative encoding, but it's oriented toward grappling with difficult-to-understand material and toward making sense of that material.

- While people sometimes engage in self-explanations spontaneously, they can also be instructed to do so—particularly beginning in middle childhood, or at around age eight. If you instruct people to engage in self-explanations, the result is better problem solving and better comprehension of texts.

- When you ask people to talk to themselves while working on learning material, some of the things they say are not self-explanations, such as "I'm confused" or "I am feeling exhausted." These don't concern the material to be learned directly, and they are not linked to better learning.

- Other things that people say are part of self-explanations and include restarting and summarizing what is in the problem or text.

- Some of what people say are what Chi and colleagues call self-explaining inferences, which are statements that go beyond what is in the problem or text and make inferences about it.

- It is specifically these latter types of statements that are associated with increased learning and, more importantly, with changes in people's models—from the naive models that are inconsistent with scientific findings to the more science-supported models.

- Siegler's and Chi's findings highlight the process of explanations in the learning of strategies and in the updating of mental models. They also point to the way that people do very well—given a lot of exposure to problems and a little support—at self-directed learning and acquisition of knowledge.

Teaching to Promote Self-Explanation and Strategy Discovery
- Discovery-based learning involves the notion that the learner should be the center of action and that the learner should be engaged actively in trying things out and making his or her own discoveries about the material to be learned. This type of learning is viewed as being most effective in the long term and as preserving the learner's own motivation.

- Discovery-based learning is contrasted with explicit teaching, or traditional instruction, which is described as focused on the authority—often a teacher, who presents material for the student to learn and directs how things unfold. Proponents of discovery-based learning argue that traditional instruction leaves students passive and unmotivated.

- A middle ground between these two extremes emphasizes guided discovery or elicited self-explanations, and the work of both Siegler and Chi would point to this middle ground as ideal. Entire educational systems have been built on these types of principles.

- On the surface, discovery-based learning sounds great, but it has some potential pitfalls.

  o First, it is labor intensive and cannot, especially at younger ages, be done with large class sizes.

  o In addition, it can be costly in material terms, though computer-aided instruction may change that.

  o Furthermore, it may take a naive student a long time to discover things that are foundational, so it may slow down the educational process.

  o Finally, at what age can we be sure that children can systematically explore an area rather than simply do a bunch of disorganized and random actions that don't teach them much at all?

- Because there has been a great deal of work in this area over the last several decades, a meta-analysis, which is a technique for synthesizing findings from many different studies to draw a general conclusion is considered more reliable and trustworthy than analyzing individual studies.

- A recent meta-analysis of about 108 studies of discovery-based learning shows that if we compare purer forms of discovery-based learning to explicit, traditional forms of instruction, explicit instruction is more effective for learning outcomes in many domains—including math and science.

- This is also true across childhood and adulthood—but the advantage of explicit instruction is particularly strong for adolescents as compared to adults—where the two forms of instruction aren't so different.

- The same meta-analysis also looked at enhanced discovery learning, which is more like the moderate approach, and found that two forms of it are generally better than other forms of instruction—and particularly so for adults and adolescents. Those better forms of instruction are elicited explanations, which is very much like Chi's work, and guided discovery, which is more like Siegler's studies.

- One feature that all forms of discovery-based learning have in common—whether they are the pure, and apparently less effective, forms or the more moderate and highly effective forms—is a focus on solving problems rather than on hearing a lecture.

- Problem-based learning is another kind of approach that is used to teach areas where people will need to engage in a reasoning process rather than simply recall facts.

- Problem-based learning is effective in arenas such as ethics, medical school, business school, and science and math—particularly where problem-based learning, as with discovery-based learning, is scaffolded by more expert individuals.

- Evaluations of problem-based learning versus more traditional approaches generally show that people are more motivated by it, but the outcomes in terms of actual learning are more mixed. It doesn't seem to do harm, and in some cases, people may be better at thinking through procedures when they have been engaged in problem-based learning.

Identifying Good Problems in Science
- While learning in science, math, and many other fields can be viewed as the process of solving problems, science is an arena where people also need to learn how to identify a good problem.

- A good problem in science is one that isn't already resolved but that can be resolved using available scientific methods and techniques and that is viewed as being important to resolve.

- Despite the ironic fact that most graduate training of scientists in various fields is aimed at teaching people to both identify and solve important scientific problems, relatively little is known about how people learn to do so.

- Creativity research based on examining the biographies of eminent individuals suggests that to produce great works, people need to first acquire a relatively high level of expertise in their field.

- Expertise provides a basis or a foundation from which to create novel works for at least two reasons: Without a basic, foundational knowledge of the area, it is difficult to avoid repeating old ideas or concepts, and that foundation provides people with a set of rules and assumptions within which creative work can emerge.

- Within a given area of science, for example, there are widely understood phenomena, and any new question will generally assume these phenomena to operate as currently understood. As someone's knowledge develops, he or she has a greater chance of being able to notice an arena where there is too little knowledge or where there is some conflict or contradictory result.

- Because science involves having guesses about how data will look and then testing your expectations, or hypotheses, against data, we learn a great deal from having our expectations violated.

- Being able to analyze and learn from the cases where our findings did not come out as we expected may be an important source of finding new questions in science.

Suggested Reading

Alfieri, Brooks, Aldrich, and Tenenbaum, "Does Discovery-Based Instruction Enhance Learning?"

Siegler and Svetina, "What Leads Children to Adopt New Strategies?"

Questions to Consider

1. Why might adolescents and adults benefit particularly from enhanced discovery learning relative to younger children?

2. Is it possible that discovery-oriented learning methods promote students' interests and desires to learn better than explicit instruction, even if they are not as efficient in promoting student knowledge?

Learning as Theory Testing
Lecture 13

W hat is behind discovery-based learning is the notion that learning proceeds like science and that people are like intuitive scientists— that they explore their environment, generate ideas about how the world works, and test those ideas. On testing, they adopt altered models that account for the results of the tests. The questions we will address in this lecture are as follows: What do we mean by saying that people are like intuitive scientists? Is that thinking true of the way nonscientists learn about their worlds? Is that thinking process something that has to be learned—and if so, how?

Distinguishing Theories and Evidence

- What is common to scientific thinking as a way of accumulating knowledge is the coordination of theories and evidence. Theories are interrelated ideas or models about how a system works, including causal relationships within the system. They are based on a body of evidence garnered from observations.

- Working scientists can articulate their working assumptions or theories, describe the evidence that would support those theories—and the sort of evidence that would raise problems for those theories—and explain the process by which they have come to endorse a particular theory, given the available evidence at any time.

- Scientific progress in understanding a phenomenon is made by positing models of the phenomenon and then coordinating such models with evidence.

- Deanna Kuhn described two ways in which we can speak of people as being like scientists in their learning. One way is to say that learning proceeds as people's models are supported or challenged by new evidence and are accordingly confirmed or revised.

Discovery-based learning suggests that learning proceeds like science and that people are like intuitive scientists.

- The second way people might be like scientists is that they deliberately and consciously examine their theories or assumptions and the available evidence. This is more like the way that scientists work, testing their models against evidence.

- The idea of self-explanations makes it seem that when people update their ideas about the world based on new experiences, they do so like a scientist. However, Kuhn and her colleagues looked more closely at the process of reasoning about theories and evidence, and they found that this is an acquired skill—and one that is quite difficult.

- To investigate these issues, Kuhn and her collaborators often follow a relatively simple strategy: They elicit people's starting theories about a situation, and present them with evidence, and ask them to put theory and evidence together.

- Kuhn and her colleagues observed that people did not do well at distinguishing theories and evidence. However, working scientists had no difficulty distinguishing their starting expectations from the evidence.

- After making the distinction between theories and evidence, people need some way to resolve contradictions between the two so that they gain knowledge. In Kuhn's work, sometimes people simply ignored evidence that didn't fit theories they held.

- This might not be such a bad strategy. Often, a working theory that we hold is something we believe because of past evidence, so we should not just toss out a good model of the world after a single instance of disconfirming evidence.

- Working scientists don't treat all evidence as equal; they consider the way the evidence or data was obtained. This is a deliberate decision to weigh new evidence differently than established evidence and to be conservative about theory revision.

- However, for Kuhn's participants, there was little sense of awareness of the distortion of evidence; participants seemed not to choose to discount some evidence but simply to ignore evidence without awareness.

- People presented with disconfirming evidence might also revise their theories to fit the evidence. However, in Kuhn's work, participants seemed to engage in this revision process not in a reflective way but, rather, in an unaware fashion. They simply shifted theories to match the evidence.

- Kuhn's findings in her early and more recent work suggest that people do get better with age at distinguishing theories and evidence, in part because of changes in basic information-processing capacities. Children are particularly weak at making the theory-evidence distinction, and adolescents are capable of doing so at more adultlike levels.

- Perhaps discovery-based learning works better for adults because they are more likely than children to be able to distinguish beliefs or theories and evidence and, thus, benefit from experimenting directly and on their own. Children and adolescents may need help with drawing distinctions between theories and evidence and coordinating the two.

- Even adults retain some significant weaknesses in distinguishing theory and evidence, particularly in more complex circumstances, where the evidence is mixed and the number of variables involved in a system are higher.

- Kuhn suggests that the cost of failing to distinguish theory and evidence is that our learning is dominated by one or the other—and although sometimes people are overly data driven, it may be more often the case that they are overly theory driven.

- In other words, this is an area of learning where prior knowledge and belief doesn't simply help us learn new information; it distorts that learning toward maintaining our existing beliefs. Often, we cannot even imagine the evidence that would contradict our beliefs.

Confirmation Biases
- Kuhn's findings and concerns point to a phenomenon called confirmation bias, which is the tendency for prior knowledge, beliefs, or theories to be maintained in the face of contradictory evidence.

- Considering the different types of learning discussed thus far, confirmation biases are relevant primarily to learning information and updating models of the world that are not purely linked to our direct experience, perhaps especially in various areas of science. Self-explanations can certainly function to support or maintain our theories.

- In the 1970s, Charles Lord, Lee Ross, and Mark Lepper found that exposing people of different initial beliefs to the same body of mixed evidence leads them to become more polarized in their opinions. Later work suggests that this is because people selectively apply their reasoning capabilities to evidence against their preferred theories.

- Confirmation biases are also evident in the arena of learning about ourselves, which is often explicitly modeled as a process of theory development and revision.

- Broadly speaking, we develop theories about what we are like—and about what others are like—during adolescence, although these initial theories draw on experiences from infancy through childhood as well.

- Thereafter, new experiences offer us evidence that either confirms or contradicts those theories based on the information offered by those new experiences. That is, new experiences offer us an opportunity to either learn that our existing views of ourselves are correct or that those views need revision.

- However, we are anything but objective and dispassionate about ourselves and our self-beliefs. One general bias is that we all like to think well of ourselves and often have a self-enhancing bias in the way we interpret evidence from our experiences. Thus, researchers note that we explain bad things by appealing to circumstances or other factors and gladly take credit for good things ourselves.

- The analogous bias to confirmation biases has been examined more extensively by Bill Swann, who correctly points out that the most compelling evidence for confirmation biases about oneself is found in people who view themselves negatively.

- In various studies, Swann has shown that people with negative self-views engage in a wide variety of strategies to ensure that their negative beliefs about themselves are confirmed by the available evidence. Swann points out that for self-views, it is easy to become trapped in the negative image of self that some people have.

- There are many studies that look at problems with people's ability to modify theories in response to evidence, and they are overwhelmingly conclusive: We maintain our strongly held beliefs in spite of contradictory evidence, and we are not highly aware of how we are doing this. Worse yet, we tend to view others with contradictory opinions as wrong.

- Where things are particularly fraught are the arenas where public decision making and science intersect, such as climate change and health care policies. These are arenas where at least some aspects of our decision making should be informed by scientific evidence, which means that the public and their elected officials need to be able to coordinate theories and evidence.

- Beyond those issues are the intergroup conflicts that are exacerbated by both sides believing that they are right and that the other side is deluded. Naive realism is the tendency we have to see our own theories and beliefs as corresponding to reality—that is, not as theories but simply as facts.

- Naive realism is in accordance with Kuhn's findings that people don't distinguish very well between theories and evidence because they view their theories as facts, and facts are, after all, a form of evidence. Furthermore, if your theories aren't theories, but are actually facts, then it doesn't make sense to change your theory in response to conflicting facts.

- Bias blind spot, on the other hand, is the tendency we have to see others as biased. (Based on naive realism, we are completely unbiased.) In fact, we are rather good at spotting other people's mistakes in reasoning and biases in interpreting evidence.

Teaching People to Avoid Bias

- There are strong links between education and the ability to better coordinate theories and evidence. Furthermore, as trained scientists generally can do this, it seems possible to train people to think like scientists about theories and evidence, and it seems plausible that people could adopt strategies to prevent confirmation biases.

- However, scientific training and acumen in one arena don't always generalize, so trying to help reduce confirmation bias tendencies won't be easy. Different proposals about how to do this target different issues. One of the most obvious is to educate people about confirmation biases.

- To some extent, educating people about biases reduces their likelihood of falling prey to them. Paul Klaczynski argues that participants in his studies within this area do not learn the skills of scientific reasoning, but rather, they learn information and techniques to ensure that they employ those skills generally—rather than only in the face of evidence they want to refute.

- Other attempts at helping people to avoid bias include encouraging them to consider the opposite. In this approach, you ask people to imagine the opposite of what they believe or the opposite of what their own findings suggest. This has had moderate success in some studies.

- A different direction might be to enhance training in scientific thinking applied to everyday issues at educational levels from kindergarten to high school. Currently, our approach is concentrated more heavily in the advanced and collegiate settings and is quite domain specific—it occurs within disciplines such as chemistry, psychology, or biology.

- A general understanding of how to think like a scientist might be useful to people more broadly if taught in a way that involved application to everyday life. This may be especially important with increasing exposure to opinion, evidence, and mixtures thereof in our multimedia, information-overloaded age.

- All of these types of intervention share an effort to move people from low-effort reliance on prior beliefs to a more deliberate and rule-oriented evaluation of evidence and theory.

Suggested Reading

Kuhn, "Children and Adults as Intuitive Scientists."

Swann, *Self Traps*.

Questions to Consider

1. Are there situations in which being right doesn't matter and confirmation biases are acceptable?

2. One issue for learning about self and others in an Internet age is the sheer amount of information that is available about one's own and others' past and present behavior. Do Facebook and other social media make it easier or harder to engage in self-confirmation?

Integrating Different Domains of Learning
Lecture 14

I n this lecture, we will consider how different domains of learning can be integrated—and where they are distinct—by way of some broad dimensions along which different types of learning can be considered. In addition, we will discuss some theories about learning as involving two types of mental processes, along with the interplay of those processes and some evidence for those theories. Finally, we will discuss strategies for learning that appear to generalize, and we will address sleep as a behavior that has been shown to facilitate learning in many different domains.

Themes for Different Domains of Learning

- On the surface, it may seem like the way we learn motor skills and the way we learn to speak have little in common—and even less in common with how we learn about science or storytelling. However, there are some ways in which learning across different content areas is similar and ways in which learning may be distinct.

- First, repetition is critical to learning in most cases. People learn by either repeatedly being exposed to information, co-occurrences, or repeatedly making efforts to do something.

- In addition, learning can be more specific and limited than we'd like. For example, when we learn motor skills, it is important that a variable skill, such as catching a ball, be practiced with varying conditions; otherwise, we can get pretty good at catching a very specific type of throw. If we need to make use of our ability to engage in good scientific reasoning, we don't always appear to do that in areas where we would rather not revise our opinions.

- Furthermore, learning depends on prior knowledge; this is true in virtually every domain we have examined, regardless of whether this notion was emphasized. In addition to its use for babies in learning about their worlds, prior knowledge can also lead us astray, as in the case of confirmation biases, and it can render it difficult or impossible to learn new things, such as particular phonemes in a second language.

- Finally, learning can happen with and without our awareness, and that is true in virtually any domain we have discussed, but different domains of learning may differentially emphasize one versus another process.

Two Systems of Learning
- Theorists have proposed two different sets of processes by which people perceive and learn about their worlds. The first type of process is a low-effort, often unconscious or implicit process that tracks associations between events. The second type of process is a deliberate, conscious, and somewhat effortful one, and it will be known as system two.

- The first type of learning process will be known as system one; it is fast, intuitive, and can process a whole lot of information without a thought or care from us. System one is related to the idea of intuition, knowing or having a hunch without knowing quite why. Recent work shows that this is not just a single system but likely a host of different systems that operate similarly—and, importantly, operate outside conscious awareness.

- System two is often discussed as being slow and has what is called low capacity. That is, there are limits to how much we can learn at any one moment in time within this system—and, again, it is possible to think of this as multiple systems as well.

- These two processes are not unique to learning; rather, they have been proposed across an enormous range of activities in which human beings and other species engage, including memory, attention, social cognition, reasoning, and decision making.

- Evidence for the two systems comes from a variety of areas, but we will consider only two: visual perception and memory.

- In visual perception, system one provides for broad attention to the environment and for picking up various stimuli while system two looks at a scene in a goal-driven way, noting and recognizing specific, desired objects or pieces of information.

- This has been shown with neuroimaging studies and also by looking at people who have specific lesions in their brains that damage areas related to one system but not the other.

- In studies of recognition memory—in which the task is to say whether something has been seen before or is new—people's judgments of recognizing something can be based on a system one feeling of familiarity and a system two actual recall of having seen the item. Both types of information—familiarity and recall—contribute to saying that we recognize something.

- When researchers look at the different contributions of the two systems differently, some revealing information can be gained. Restricting recognition only to items that people actually remember results in lower performance, so system one does appear to let us recognize more information than system two.

- In addition, looking at people or circumstances that make deliberate recall difficult suggests that deliberate recall and familiarity are two distinct systems. The two systems involve different areas of the brain in neuroimaging studies as well.

- One proposal from reasoning and decision making is that when these two processes result in different outcomes, we have a chance to override our default intuitions, which are based on system-one thinking, via deliberate and effortful involvement of system-two processing. In essence, this is what is required to overcome confirmation biases, but these systems also interact all the time.

Enhancing Learning
- It's no surprise that practice and rehearsal support learning. If you consider spatial learning, motor learning, and even learning to tell stories, it's important to practice and rehearse in particular ways.

- In general, practice and rehearsal that are spaced over time—that is, not all right before you have to show your learning, but occasionally in small increments—is more effective. This is true for reviewing vocabulary words, learning to play a musical piece, and developing a map of a new town.

- Researchers such as Robert Bjork think that our brains evolved to learn and retain skills and information that we have to use over time—not to waste energy retaining what we only use once. Therefore, spacing rehearsal over time appears to make it clear to our brains that we can't lose track of a skill or ability because we will continue to need it.

- In part, the fact that elaborative encoding works means that we connect to what we already know—either deliberately, by thinking about how information connects to past knowledge or personal experience, or implicitly, as when we learn a motor skill and our body makes use of past movement patterns to acquire a new one.

- It is not surprising when studies find that we learn better with information presented in more than one modality—if we both see and hear information, for example, or if we experience both motor and spatial learning.

- Practice and rehearsal that are variable, rather than precisely the same, work better for learning in most cases because variable practice means you learn material in ways that are more easily available in a variety of situations. Therefore, studying and retrieving vocabulary words in different contexts and settings, and in different ways, is important.

- Variable practice and rehearsal allows you to really learn things—not just temporarily memorize them for a test. Sometimes, this type of variation has unanticipated benefits. In fact, a recent study of category learning promotes this idea of variability even in the area of category learning and for children as young as 18 months.

- Practice and rehearsal that correspond to how you need to use your learning are likely to be more effective than if they are not relevant to how you will use your learning. In most cases, this means that you need to practice in ways that are similar to use. For motor learning, for example, you can practice by visualizing and observing, but you'll eventually have to actually do the task to get better.

- You can also be strategic about the interplay of the two learning systems. For example, immersion probably aids second-language learning because it involves that implicit statistical tracking system, even when you don't think you are actively learning the language.

- Some situations call for more use of system two than seems to occur naturally. For example, when grappling with new evidence, you want to bring system two fully on board because it allows you to distinguish theory from evidence and to evaluate the quality of each piece of evidence.

Sleep and Learning
- After you rehearse and practice, one of the best things you can do for learning may be to sleep because sleep allows your brain to finalize the various neuronal connections you forged through learning and practice.
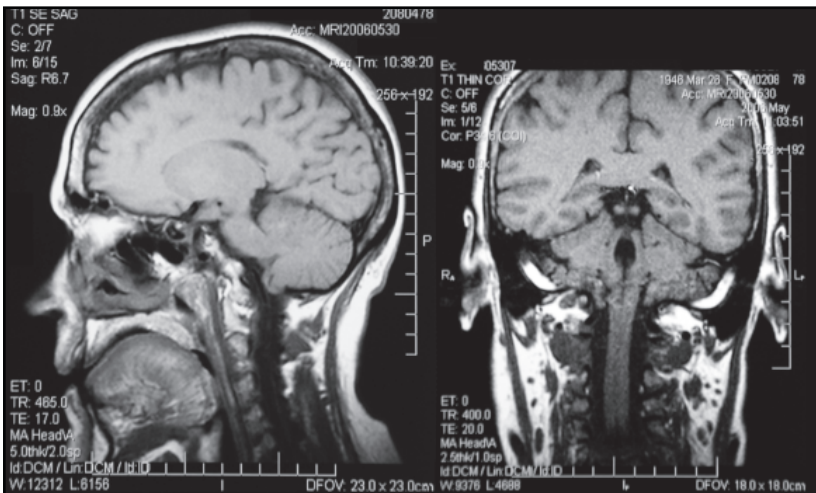
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Images of the brain's activity during sleep suggest that it might be replaying learning during the REM stage.

- Sleep involves a change in people's states of consciousness, and it is divided into stages: REM sleep is characterized by rapid eye movements and a lot of brain activity along with muscle paralysis; stages one and two involve relatively light sleep with rapid brain waves; and stages three and four involve deep sleep characterized by slow brain waves.

- People cycle through these stages in 90-minute intervals, with REM sleep occurring throughout the night. In the early half of the night, we spend more time in slow-wave sleep while in the latter half of the night, we spend time in stage two and REM sleep.

- REM and slow-wave stages of sleep may be critical for learning. Studies have looked at people trying to learn under conditions of sleep deprivation, and it seems that learning is impaired under these circumstances. Therefore, you should try to rest before you learn.

- Far more studies have looked at the role of sleep in consolidating learning—in other words, whether sleep helps you retain learning longer or improve memory. This can be studied by looking at a participant's memory for what they have learned after a delay that either included or did not include sleep.

- Across an enormous range of learning domains, sleep appears to improve retention of foreign vocabulary, motor-sequence learning, and even discrimination learning. In addition, at least with motor and visual learning, short naps during the day enhance performance compared to not napping.

- Research suggests that your brain might be replaying learning while you are engaged in REM sleep. This is documented by comparing images of brain activity during learning with brain activity during REM sleep, and some findings suggest that for motor learning, these relationships can be seen fairly clearly. In this way, sleep acts as an extra rehearsal.

- Recent evidence indicates that the belief that people don't make new neurons as adults—that people have all their brain cells at birth—may not be true. In particular, the hippocampus is a location where new neurons are generated in adult mammals.

- The hippocampus is an integrally important part of the brain for learning and memory. Sleep deprivation—during both REM and stage four sleep—may reduce the extent of building new neurons in the hippocampus after learning and disrupt the ability of those cells to develop into mature cells. Without building those neurons, and letting them mature, you are hampering your memory capabilities.

Suggested Reading

Evans, "Intuition and Reasoning."

Perry, Samuelson, Malloy, and Schiffer, "Learn Locally, Think Globally."

Questions to Consider

1. Can you think of recent experiences where you have had to correct an initial intuition or judgment based on deliberate reasoning? How did you realize you needed a correction?

2. There are concerns about the rising use of Ritalin and other stimulants by college students to reduce their need for sleep. What might the use of such medications mean for learning?

Cognitive Constraints on Learning
Lecture 15

In this part of the course, we are shifting from looking at specific types of learning to looking at factors that can influence learning more broadly and across different types of learning. One of these sets of factors involves three interrelated, interconnected abilities: attention, working memory, and executive function. In this lecture, we'll consider the evidence for the importance of these capacities in supporting—or limiting—learning. We will also talk about whether and how these capacities can be improved or supported to enhance our learning abilities over our lifespan.

Attention

- Attention is the focus of your conscious awareness. Sustained attention is the capacity to keep paying attention to something over an extended period of time. Divided attention is the act of switching back and forth between two different tasks. Selective attention involves focusing on one thing among many competing, distracting items.

- Usually, we assess these distinct capacities for attention in laboratory tasks that, for example, look at how well we can identify one item within an array (selective attention), how long we can track a particular image as it moves around (sustained attention), or how well we can switch between two competing tasks (divided attention).

- These ways of measuring attention show that attention is a limited resource; we cannot pay attention to everything within our visual field, everything we hear, or everything we feel.

- Attention plays a very important role in learning because what we do not attend to is often not learned. However, there are some exceptions to this that involve tacit learning.

- Attention is so powerful in ensuring that we learn things that attention researchers have discovered a series of phenomena, including inattentional blindness and change blindness. Essentially, if you are not attending to something, even if you are looking directly at it, you don't see it, and what you do not see you cannot learn.

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Divided attention involves switching focus between two different tasks, such as text messaging and doing schoolwork.

Working Memory

- Once you've paid attention to something, in most learning situations, that's not the end of it; rather, when you engage working memory in the service of learning, it is within working memory that you are actively connecting new material—material to be learned—to what you already know. This is a process that is similar to the idea of elaborative encoding.

- Furthermore, and perhaps most importantly, the use of working memory need not be focused specifically on learning. In fact, you are likely to learn what you engage with in working memory even if the reasons you are engaging with it are not explicitly about learning.

- While intending to learn or not learn information may not matter, intentions do influence what you pay attention to and how you engage with it in working memory.

Executive Function

- Executive functions are the array of abilities that comprise planning, flexibility, and inhibition; they are connected to the ways in which we deliberately employ, shift, and focus our attentional capacity and make use of working memory capacity in the service of our goals.

- Planning is the capacity to think through a complicated task so that you don't make early errors that are costly. One way that planning gets assessed involves tasks with various rules or constraints, and you have to find a solution that does not violate the rules.

- An example of a planning task is the Tower of Hanoi problem. In this problem, you have two platforms with three pegs that hold various disks, and the general task is to match one platform to another platform in terms of disks and configurations. This task requires people to visualize moves ahead in order to avoid being in a situation where they cannot follow the rules of the game.

- Flexibility is the capacity to change from one set of rules to another. For example, a researcher might ask you to sort a series of cards with shapes of different colors on them; first, the researcher might ask you to sort them by color and then by shape. The more errors you make when you have to switch tasks, the lower your cognitive flexibility is.

- Inhibition is the ability to ignore distracting information. For example, in what is called a Stroop task, a researcher might ask you to look at a series of color words printed in different ink colors. In some cases, the words are printed in the same color that they name, but in other cases, the word "red" might be printed in blue ink, for example. Your task is to name the ink color—not to read the word. In this task, the word meaning becomes a distraction; it interferes with your task, which is to pay attention to the ink color.

- By measuring how quickly you respond in those conflicting cases versus the congruent cases, where name and ink color match, the researcher has a measure of how effectively you can inhibit the distraction of the word meaning. The bigger the discrepancy—the more that conflict slows you down—the more trouble you have with inhibition of distracting items.

Executive Function in the Brain

- Executive functions are housed in the prefrontal cortex of the brain, and there is a way in which this is a more-is-better situation. Some of the best illustrations of this come from cross-species comparisons.

- Different species of primates have different amounts of prefrontal cortex, and this matters for how well they perform on executive-function tasks. For example, the reverse reward task is a difficult task for animals in which they are shown two different piles of food and are allowed to point to one. The trick is that they receive the pile that they do not point toward, and consistently choosing the smaller amount of food requires inhibition.

- Different species of monkeys perform differently on such a task, and the differences between them depend on the size of their prefrontal cortex. Different ages of humans also have different amounts of prefrontal cortex, which is one of the latest-maturing parts of the brain that is an area of significant age-related decline in later adulthood.

- Attention and working memory are critical for learning, and executive functions allow you to direct and control these processes—and, more broadly, your behavior. These abilities help to determine what gets perceived and encoded and to retrieve information or engage in a skill at a later point in time.

Enhancing Attention, Working Memory, and Executive Function

- Researchers are identifying ways to improve the capacities of attention, working memory, and executive function and, therefore, to make learning more effective and efficient for people.

- The main way that executive function and attentional processes can serve learning is by allowing us to strategically focus on different aspects of the material to be learned and also to manage both what we are trying to learn and other competing demands on our time and attention.

- In variable priority training, which was developed as a method of improving people's ability to do two things at once, people are asked to learn to do two different tasks at the same time, shifting their priorities of the tasks at various points in time.

- Variable priority training is performed in laboratories with laboratory-like tasks, so one of the major issues with these approaches is what is called transfer, which refers to whether learning one type of task—the one used in variable priority training—will actually benefit you in some other task, such as executive function or even learning capacity.

- In one study, Art Kramer and his colleagues asked older and younger adults to learn to simultaneously perform an alphabet-arithmetic task and to monitor a set of six gauges that changed continuously. The results showed that variable priority training was better than fixed priority training; this was true for both older and younger adults and for both being able to perform the training tasks and being able to perform quite different tasks.

- Variable priority training is being built into software packages for improving cognitive function among adults and for better preparing young children for school. However, these products are often untested, and they often depart from the types of laboratory tasks that have been evaluated in order to create a more marketable and appealing product.

- Mindfulness meditation is a practice that originated in Buddhist traditions and is geared toward increasing people's mindfulness, which is characterized by two major features: full attention to the current, moment-to-moment experiences—both internal to oneself and external—and an attitude of being open and nonjudgmental.

- Mindfulness meditation has been incorporated into a number of psychological treatments and is linked to many positive outcomes for people who practice it: higher well-being, more control over substance use, lower blood pressure, less emotional distress, and benefits for chronic pain and other disorders.

- Because mindfulness encourages people to focus their awareness in the present rather than being distracted by concerns about the past or future, it could also help to expand attentional capacity.

- A recent review of a number of studies suggests that asking people to engage in mindfulness meditation practices appears to be linked to improvements in attention, working memory, and executive function. Furthermore, long-term meditators show better performance on these types of abilities.

- Another way to improve mental capacities is bilingualism. Ellen Bialystok and her collaborators have been studying bilingual individuals for many years, and they consider people bilingual if they regularly use two languages.

- Bialystok has found that people who are bilingual show above-average performance on working memory capacity and executive function—particularly regarding inhibition of distractions and flexibility.

- Bialystok speculates this is because in order to switch back and forth effectively between two languages, people need to use executive abilities. In addition, she and her colleagues have shown the same effects across different languages.

- These advantages for bilinguals actually grow larger over time; in other words, the way that bilingualism enhances executive function seems to be increasingly evident as people grow older—a time when executive function is often on the decline. Some evidence suggests that bilingualism may even protect against dementia.

- However, it isn't clear if people who learn a language later in life will experience benefits, and it isn't clear what happens if people once were functioning as bilinguals but now largely function as monolinguals.

- Another intervention to improve executive functions is called dramatic play. There are many computer games that are being developed for these purposes, but they aren't well tested for the most part.

- Work done by Adele Diamond and her collaborators has shown that getting young children to engage in dramatic play—role-playing and pretending, for example—improves executive functions. This is probably because such play requires children to take turns, wait to talk, inhibit some actions, and focus their attention on what is happening around them.

- These findings apply to at-risk children, whose initial executive function in preschool was not great. In addition, they underscore the value of a broad curriculum for children. Finally, they suggest that as adults, we might maintain and even optimize executive function by playing more often.

Suggested Reading

Diamond , Barnett, Thomas, and Munro, "Preschool Program Improves Cognitive Control."

Hertzog, Kramer, Wilson, and Lindenberger, "Enrichment Effects on Adult Cognitive Development."

1. Are there ways of structuring a learning experience so as to avoid demands on attention, working memory, or executive function?

2. What might be adult analogues of dramatic play in childhood? How might such activities enhance or help to maintain executive function in adulthood and later life?

Choosing Learning Strategies
Lecture 16

I n this lecture, we will discuss how our attention, working memory, and executive function allow us to monitor our learning. In any learning situation, we need to be able to devote some attention, working memory, and executive function to whether we are learning effectively, and judging our own learning is an important part of the process. If they are accurate, judgments about our learning can be very helpful. Knowing how to effectively use your judgments of learning will allow you to become an active, purposeful, engaged learner rather than a passive recipient of learning.

Judgments of Learning

- Judgments about our learning can tell us what we know and what we don't know, which also tells us what we need to focus on in a learning situation, whether we have learned something well enough to remember it later or perform it well, and whether we need to invest more time and effort in learning something. This is monitoring our learning progress.

- Additionally, if we need to invest more time and effort, our understanding of our own learning also encompasses the best strategies for how to invest that time and effort so that it pays off.

- The accuracy of our judgments of learning and choices about strategies is complicated by the issue that there are many different types of judgments and choices that we might be making.

- Judgments of learning are assessments of the extent to which you feel you have learned something. Often, in the laboratory, these judgments are studied in relation to learning a list of words or word pairs.

- In these settings, we can ask a couple of questions. First, how accurate is someone at predicting whether he or she has learned a word pair? This is a measure of absolute accuracy. You can also ask whether a person's judgments help differentiate between what they did and did not learn. This is a measure of relative accuracy.

- Generally, both types of accuracy are important, but in terms of allocating study time and employing study strategies, relative accuracy is a more important outcome.

Factors That Influence Judgments of Learning
- The accuracy of people's judgments of learning depends on a variety of conditions, and we are vulnerable to getting tricked in a variety of independent ways—that is, we can be inaccurate under some predictable circumstances.

- One important contribution to accuracy is when you're asked to make the judgments. If you are asked to judge your learning immediately after you have studied some items, you tend to overestimate your learning. Accuracy is enhanced if you wait a while and then ask how well you learned something.

- This is likely because in the immediate moment, your new learning is very accessible and feels very real; after a delay, you have a more accurate sense of whether you learned material because you don't have that immediate illusion that you really know it.

- We also base judgments of learning on irrelevant things. One of those things is the ease of processing the information in the first place—not the ease of learning, but the ease of just seeing the stimulus.

- For example, if you are presented with words, and some are presented very loudly while others are presented very softly, you will judge the loud words as better learned than the soft words. In fact, loudness of presentation has no bearing on recall; softly presented and loudly presented words are just as easily learned and remembered later.

- Researchers felt this might have to do with a sense of effort—that is, the more effortful it is to process information, the less well we think we have learned that information, regardless of whether that is true.

- Another factor that influences judgments of learning is how much time we've spent studying, but this factor is much more complicated than the others. In some cases, the more we study something, the more we judge we've learned it. However, in other cases, the more we study something, the less we judge that we've learned it.

- This only makes sense if you think about two different factors underlying study time: We study things longer if they are more important to learn and then view them as better learned, but we also study things longer if we think they're harder and then give them lower judgments of learning.

- Through their research, Asher Koriat and Ravit Nussinson showed that judgments of learning depend on our sense of effort and on our interpretation of that sense of effort. Specifically, when we interpret the effort as related to item difficulty, we downgrade our sense that we've learned the item. When we interpret the effort as related to us investing in learning, we upgrade our judgments of learning.

Using Judgments to Guide Learning Behavior
- A discrepancy reduction account is an approach in which you use judgments of learning to determine what you don't know, and then you invest time and study actions on what you don't know very well yet. Much of this work focuses on study time—not on how people learn.

- This discrepancy reduction account leads to the expectation that there will be a negative relationship between judgments of learning and allocations of study time; the more you think you know it, the less you study it.

Judging your learning involves knowing what you know and knowing the best strategies for maximizing learning.

- Across 16 studies in which researchers measured both judgments of learning and study time, 13 showed a negative relationship between the two, and 3 showed no relationship.

- More broadly, many studies show that people allocate more study time to more difficult items, and they also judge learning of such items as lower. This is consistent with the idea that judgments of learning are associated with strategic allocation of study time. However, the relationship disappears when people are under time pressure and when well-learned items are taken out of the to-be-studied items.

- These types of findings led to a different notion of how judgments of learning influence study behavior—again, in terms of time—and that is the region of proximal learning framework, in which people stop working on studying what they have already learned and then focus on the easiest of the items remaining in the material to be learned, shifting gradually toward more difficult items as they feel they have mastered the easier remaining items.

- We do this in part because the payoff of investing time in the easiest stuff we have not yet learned is likely to be very high. By contrast, a discrepancy reduction model means you could keep investing study time in items that are very difficult to learn—those that might consume your available time. However, there are important possible costs for eliminating easier and already-learned items from the study pool.

- The most effective strategy for learning is to repeatedly retrieve both items that are known and items that are not as well known. In studying, when we choose to recall only the items that we haven't yet mastered, we run into a memory issue that can disrupt learning called retrieval-induced forgetting.

- In retrieval-induced forgetting, people learn a set of items on a list. Then, they selectively practice only some items and are asked to not practice others. Over time, people show forgetting of the unpracticed items that is more than you'd expect; it's as if failing to practice these items makes them unlearned.

- This raises some questions about whether we know what strategies work best even when we use judgments of learning to focus on what we haven't yet mastered.

- Because every retrieval we do of something we learned is another rehearsal opportunity, repeated testing means repeated practice of the thing you're trying to learn to do. In many cases, it is impossible to rehearse something without repeatedly testing ourselves, so studying and testing are the same.

- However, in other cases—for example, when learning foreign vocabulary—you can study words by looking at them rather than by trying to generate them from scratch. The latter is more like testing.

- We know that repeated testing is extremely effective for learning and retention of learning—more than simply studying materials that can be studied in non-test-like ways.

Research and Learning Strategies

- A series of experiments by Jeffrey Karpicke suggests that in many cases, we don't make good choices about using repeated testing. To investigate this, Karpicke did a series of four experiments in which foreign Swahili word pairs were studied.

- In the first study, Karpicke found that judgments of learning were highest for people who kept studying all the word pairs—higher than for those who dropped word pairs they had learned and for those who were repeatedly tested on already-learned pairs. Therefore, repeated testing doesn't increase judgments of learning.

- Karpicke also found that people's learning of the vocabulary words, as assessed one week later, was far higher in the repeated testing condition. This shows that people didn't realize that repeated testing was producing better learning.

- In the second experiment, Karpicke found that, given the choice, participants usually chose to drop items they had learned, to repeatedly test words that they were fairly confident of having learned, and to repeatedly study words they were less confident of having learned. Notably, this amounts to using your less effective strategy on the words that you think require the most learning.

- In the two additional studies, Karpicke showed that attempting retrieval early—before people have learned much—substantially improves the effects of studying. In other words, forcing people to take a test well before they are ready meant that afterward, in studying, they learned more. In addition, Karpicke found that people did not make use of this approach; given the choice, they opted to delay testing and to engage in more study.

- Research suggests that our judgments of learning are tightly tied to effort and that they are accurate enough to serve as a guide to where and how to invest learning efforts. Furthermore, we're fairly decent at monitoring what we do and do not know, and we can be subtle and strategic about how we use that information to determine what items deserve our studying effort in terms of time.

- The bad news is that we tend to stop studying and testing ourselves on things we believe we've already learned. However, this is a way to unlearn those things. Therefore, once you've learned something, that doesn't mean you should stop trying to retrieve it.

- Additionally, we tend to make far too little use of testing as a strategy for learning. We don't use repeated testing as often as other, less effective strategies—such as rereading or studying items—and we use it late, when we feel we have learned things.

- Unfortunately, early in the learning process, testing appears to make studying work more; in a way we should begin with testing and then move to studying, but people prefer the reverse order. To increase learning, study by testing yourself, and use repeated testing for material that might not otherwise lend itself to that approach.

Suggested Reading

Weinstein, McDermott, and Roediger III, "A Comparison of Study Strategies for Passages."

Zaromb, Karpicke, and Roediger III, "Comprehension as a Basis for Metacognitive Judgments."

Questions to Consider

1. Why do you think people avoid engaging in repeated testing while trying to learn material? What could be done to encourage students to use this extremely effective strategy?

2. Considering earlier lectures on different types of learning, why do you think repeated testing is so effective as a learning strategy?

Source Knowledge and Learning
Lecture 17

I t's important to monitor your learning so that you can choose wise strategies, but it is also important to consider the source of your learning—learning where, when, and from whom you are acquiring a piece of information—because not all sources are equally reliable, valid, or trustworthy. Learning source information, also called source monitoring, is a very important part of learning. This lecture is about learning information that helps you decide whether other information is worth learning—or how much weight to give other information when pooling information from many places to learn about a topic.

Source Monitoring
- Source monitoring refers to learning the source and circumstances where we learned a fact, along with the fact itself. Many of the judgments we need to make relatively often in our lives depend on learning the source of a thought, image, or memory as well as the contents of that memory.

- The problem is that we do not appear as well suited to learning the source of our information as we are for learning the information itself. There are separate brain circuits involved in learning source information, for example, and many studies show that our memory for the content of information we have learned is superior to our memory for how we learned that content—where, when, and from whom.

- This divergence in our ability to learn sources versus information first became evident in the context of what is known as the sleeper effect in persuasion. Research on persuasion, in contrast to learning, is focused on how to change people's beliefs or attitudes toward something.

- In a typical persuasion experiment, you are exposed to some type of argument in favor of a particular position, product, or person. Researchers then vary pieces of that argument to see what factors make it more or less effective.

- For example: Does it matter if it is a famous actor endorsing the politician versus a random person? Are complex, elaborated arguments more effective than simple claims? Do those factors depend on something else, such as characteristics of the audience?

- Early on in this area of research, people became interested in what was termed source credibility—that is, if a plumber tells you about a toilet maintenance product, you might take his opinion seriously, but if your mechanically inept friend tells you something similar, you might not.

- Immediately after hearing a message, the credibility of a source matters in this way. However, over time, the low-credibility source message becomes more persuasive. This is what is called the sleeper effect because it is as though the not-very-credible message is just slumbering in your brain until it suddenly pops up as influential.

- The explanation for this effect has to do with the fact that we are fairly good at learning information that is important to our goals and concerns; we often don't have to try very hard for that type of learning. Unfortunately, we are much less good at remembering exactly where, when, and from whom we learned a piece of information. Because of this, the low-credibility source information fades in time and makes space for the message to stick around and influence us.

- There are serious issues that our bad source-learning ability can raise. One is unconscious plagiarism, which happens when we have a brilliant insight or way of expressing an idea that we think is ours but that, in fact, belongs to someone else.

- An issue surrounding eyewitness memory is that we can become confused about whether we saw something happen or heard about it from other eyewitnesses after the fact. Information from the event itself, from discussing it with others, and from reading about it in the news can all get mixed up in ways that are difficult to disentangle later.

- Another issue involves knowing whether we did something or just imagined it. This is called reality monitoring, and it has to do with whether the source of something we have learned is a real source or just the thoughts or imaginings in our head.

Factors Affecting Source Learning

- Age is related to source learning in several ways. Young children are very bad at learning the source of their experiences as compared to young adults, and older adults are also relatively bad at source learning.

- While we can't do much about being young or old, it is worth knowing that age can put us at a disadvantage in terms of learning where, when, and from whom we have learned something because we can choose to be more careful about our source learning.

- A second factor that influences source memory in ways that can help or hurt us is the use of schemas about a source. We usually have pretty well-developed ideas about sources of information; in fact, that is part of what allows us to know whether a source is credible or not.

- We also have expectations about what others might say or think based on our knowledge of them. When we are trying to figure out who recommended a book, for example, we are likely to use constructive processes to try to remember, based on who we discuss books with and who would like this type of book. We want to know who recommended the book because that tells us how much we should consider buying it. However, this type of constructive, expectation-driven way of trying to guess a source is likely to lead to biases.

- When schemas are violated, it is sometimes easier to learn, provided that you are thinking about your expectations in the first place. For example, if your mother has never recommended a book to you and then does, the fact that you are surprised by this might make it easier for you to remember the source. If you're more focused on trying to remember the name of the book so that you can buy it, however, you might be less likely to recall the source of the recommendation.

- As with other aspects of learning, when we fail to learn something well enough, we make use of existing knowledge to create an educated guess about that thing; in the case of sources, our schemas will often be correct, but they will sometimes be wrong.

- A third factor that influences source learning was identified in a meta-analysis of experiments on the sleeper effect in which researchers confirmed that the sleeper effect exists and is not trivial. They also found that the sleeper effect is very much driven by either failing to fully learn or ultimately forgetting the source of information. Additionally, it matters how you process information about the message and about the source of the message.

- In many cases, people apply different approaches to the information and to the source of the information. It is more likely that you don't pay any attention to the source beyond a cursory nod—one that makes more use of what are called heuristic cues about credibility rather than carefully thinking about the meaning of the source for the information that is being presented.

- Work on unconscious plagiarism reveals another factor affecting source learning: When you encounter information and think about it yourself, it complicates the issue of where a thought originated.

Recalling the source of a particular fact is sometimes just as important as learning the fact itself.

- In one study, researchers used an idea-generation paradigm to look at how people come to believe that others' ideas belong to them. Participants first generated ideas in a group, but then they were asked to think about their own and others' ideas more, under a variety of conditions. The condition in which participants were asked to think about the idea and how it might be improved upon made it more likely that people later recalled those ideas as their own—even when they were initiated by others.

- Finally, some researchers point out that there are important clues to source in memory phenomenology. When something actually happened—rather than being just imagined, for example—we tend to remember that event with the perceptual and sensory detail that it had at the time it occurred.

- By contrast, when we just imagine something, we may have memories of our thoughts and feelings, but we tend to have less of a sense of sensory and perceptual detail. Likewise, if we saw something occur, we tend to have perceptual and sensory memories, but if we read about it, this is less the case.

- What this line of thinking suggests is that if people are asked to attend to the sensory and perceptual aspects of memories, they may be better at recalling source information than if they are asked to attend to other types of information, such as their own thoughts and feelings, because these are not so good at distinguishing the source that gave rise to them.

- Research findings point to the fact that if we pay attention to source information and think about what it means—if we elaboratively encode source information—we are able to learn it just fine.

- Elaborative encoding includes paying attention to the source when we are learning, thinking about the meaning of the source for the message in an elaborated, and paying some attention to the sensory and perceptual aspects of a learning experience. These features help us to later remember the source of information.

Source Learning and Modern Society
- In today's information-rich society, we can learn about topics from many different sources, so issues of source learning become important for how we integrate that information into our own understanding of a phenomenon. In fact, an understanding of sources and an ability to weigh them appropriately can be critical in determining how well people understand the phenomena they study.

- In learning about climate change, for example, people might consult a wide variety of sources, including news reports from conservative and liberal news outlets, scientific reports, government documents, press releases from universities, blogs on the Internet, popular magazines, and textbooks.

- To draw conclusions across all these sources, people need to be able to put the texts together and make sense of them, and they are likely to conflict with one another. Furthermore, people need to weigh the sources appropriately, giving less credibility and less weight to information from sources that have obvious conflicts of interest— such as oil companies or highly partisan wildlife protection groups.

- Research in this area has shown that better source learning is associated with better integration across different sources of knowledge. Thus, source learning is critical for avoiding influence by information we'd rather not learn. It may also foster better capacities to integrate information from multiple sources in a way that takes into account source credibility.

- There are many circumstances in our everyday lives in which it is important not only to know what we have learned but also to recall the circumstances under which we learned it—perhaps especially the source of the information. Our tendency is to fail to do so, with some predictable consequences, but some findings suggest that we can do better and that doing better improves learning of what we want to know and helps keep questionable information out of influential range.

Suggested Reading

Kumkale and Abarracin, "The Sleeper Effect in Persuasion."

Stark and Perfect, "Whose Idea Was That?"

Questions to Consider

1. When is it critical to focus attention on and attempt to learn source information? When is it less critical to do so? Are there times in the lifespan when source learning is less important?

2. What might be the utility of having a mind that learns the information itself better than when and where the information was learned and from whom?

The Role of Emotion in Learning
Lecture 18

I n the past three lectures, we've considered aspects of how we learn that involve the dry facts of where, when, and from whom—what strategies we employ, what we know about what we've already learned, and what basic cognitive capacities we are applying to learning. Part of how we learn involves how we feel and what we want when we approach learning. In this lecture, we'll move to considering these less dry aspects of learning—how what we are feeling affects what we learn and how what we want to know might do the same.

Studying Emotions

- Emotions are defined as a temporary state of a person that entails coordinated patterns of physiological arousal and mental states that can promote emotionally relevant patterns of behavior. In fact, people can experience the physiology of a particular emotion, and sometimes even the subjective emotional state, by posing their faces in the right way.

- Many researchers believe that emotions have an evolutionary basis, and this is important to consider in thinking about how emotions may affect learning. We share basic emotions with many other animals; for example, rats demonstrate anxiety, and dogs show depression.

- Theorists believe that negative emotions, which are triggered by threatening situations, such as anger and fear served to motivate fight-or-flight responses in our evolutionary history. On the other hand, happiness, pleasure, and joy are less clearly evolutionarily functional.

Researchers often induce particular emotions in participants by showing them certain film clips and images.

Negative Emotions and Learning

- The possibility to induce emotion in the lab is what permits researchers to investigate the impact of emotional states on learning. Researchers do this in a variety of ways—from asking people to remember autobiographical experiences that involved particular emotions to showing them film clips and images or playing musical selections that induce particular emotions.

- Many researchers use film clips and images because these materials allow us to expose everyone to the same event or experience in order to make them, for example, fearful. By contrast, using our own events introduces individual differences as factors.

- When we think about how negative emotions affect learning, we need to consider what they have in common, which is unpleasantness, and where they are more distinct, which involve arousal and specific action tendencies.

- Negative emotions appear to narrow our attentional focus, which allows us to be better at learning details about an emotionally negative stimulus than a neutral stimulus.

- In some of the earliest studies, participants would be asked to learn a series of images from slides. Most of the slides would be neutral, but a traumatic slide in the middle was both learned and later remembered. Interestingly, people were remarkably unlikely to recall the slide immediately before or after the traumatic slide.

- Researchers view this as an adaptive attention and learning phenomenon; things that don't matter much are learned when there is nothing more serious going on, but something that is threatening is what you should pay attention to and remember.

- Elizabeth Kensinger showed people a set of images and then asked them to look at a second set of images. In the second set, some of the objects were identical to those in the learned set, others were similar, and some were new. People had to judge whether the objects were identical, which required memory for details, or similar, which just required memory for having seen a particular image. People's memory for details was significantly better for negative images.

- In subsequent work, Kensinger and her colleagues showed that negative stimuli don't just get better learned in general; in fact, we learn the important and central details of negative things and are more likely to forget the peripheral, less important details.

- One study made participants feel sad or happy and then asked them to learn a neutral task. Then, participants were asked to do new tasks to see whether their learning transferred. Participants in a negative mood when learning performed more poorly than those in a positive mood. Participants in a negative mood while trying to generalize their learning to new tasks needed more time to do the transfer tasks and did more poorly at those tasks.

- While fear might enhance learning of threat-relevant information, sadness might suppress learning performance. It is less clear what anger does, but findings in this area suggest that it operates similarly to fear in narrowing attention toward relevant, central details.

- Although some negative emotions may help to focus attention and improve learning of critical, threat-relevant details in the moment, others have shown that over the long term, negative emotions in academic contexts are linked to lower student involvement and motivation; to students being less likely to use more effective learning strategies, such as elaborative encoding; and to students learning as indicated by their academic performance.

- Negative emotions generally seem to narrow attention and focus it on information that is most relevant to the immediate threat, thus enhancing learning of the most important information for the person at that moment and suppressing learning of less relevant information.

- When there is no immediate threat, negative emotions appear to generally suppress a number of factors that we know promote better learning and, ultimately, to have a negative impact on learning itself.

Positive Emotions and Learning
- Positive emotions really don't involve physiological arousal; rather, they are characterized by a lack of stress-related arousal. Additionally, positive emotions really don't promote any specific actions.

- Given the association of positive emotions with lower levels of arousal, Barb Fredrickson discovered that being encouraged to experience positive emotions after negative ones speeds up our return to a baseline, neutral level of arousal.

- In looking at a variety of research findings on creativity, broad thinking, and even artistic temperaments, she also discovered that the function of positive emotions was to support people in broadening and building; in other words, positive feelings support us in acquiring resources for the long term whereas negative emotions support immediate, focused action in response to important, present threats. These resources might take many forms to establish new social relationships and to affirm existing ones.

- Positive emotion also supports us in exploring our environment, and exploration is fundamental to learning. Attachment theory was based on the idea that babies need a secure relationship to their parents in order to explore the environment, and babies who are afraid don't explore. One way to articulate this idea in a more succinct manner is to propose that positive emotions broaden our focus of attention.

- Some studies of learning and emotion show strong relationships of positive emotions in academic settings to motivation, learning strategies, and actual academic achievement. The problem is that the students who were feeling less positive may have already had difficulties with the material and, hence, ended up with lower grades because of less ability or poorer preparation.

- Therefore, to assess causality, studies need to be able to make people feel positive emotions, and they need a way to examine whether the focus of attention is broad or narrow. Additionally, they need to compare positive emotions to a neutral state and to show that different positive emotions—such as amusement and contentment—work similarly to broaden attention.

- To make people feel positive, one strategy is to use brief two- or three-minute film clips. Film clips of penguins at play, for example, are used by Fredrickson and her colleagues to create feelings of amusement while scenes of nature are used to create serenity and contentment. To create a neutral state, film clips of random patterns can be used.

- To examine whether participants had a broader attentional focus after the positive-emotion film clips, Fredrickson and her colleagues used a task that assesses a preference for global (general) versus local (detail-oriented) processing of visual images after participants first viewed an emotion-inducing film clip. Participants in the positive-emotion conditions had significantly more global responses than did participants in the neutral condition. Furthermore, it didn't matter which positive emotion the person was feeling.

- Importantly, attention is not the same as learning, but having a broader attentional focus might increase the amount of information people are able to take in—in contrast to the effects of negative emotions.

- In addition, positive emotions may help to maintain motivation to learn. Amy Reschly and her colleagues looked at positive emotion and academic engagement in a sample of high school students. Students who reported frequent positive emotion in school also reported higher levels of engagement with learning—although Reschly and her colleagues did not have assessments of whether students actually were learning more effectively.

- In another study, researchers looked at positive emotion over the course of a semester for college students, and students who reported lots of positive emotions in the context of classes ended up using better learning strategies, being more intrinsically motivated by school, and ultimately, performing better.

- There are problems with interpreting such research as definitively showing that emotions cause changes in learning because students with more positive emotion may have simply been more capable, more knowledgeable, or otherwise better prepared—so the emotions might not have played a role in better learning outcomes.

- A more recent study in this arena took an experimental approach and focused more explicitly on category learning. Ruby Nadler and her colleagues used music and video clips to discover that being in a good mood enhanced people's ability to learn complex categories that were rule based correctly.

Negative versus Positive Emotions and Learning
- Good moods lead to broader attention, better category learning, and better longer-term academic learning. However, the more creative, attentionally broad cognitive approach that people in a good mood have is specifically good at enhancing transfer; people who learn a task do better at transferring that knowledge to similar problems when they are in a good mood.

- It's clear that emotions influence learning at many phases of the process: They influence the breadth or narrowness of attention, the extent to which we actively seek information, the way we approach the information we get, the speed with which we learn, and our ability to generalize what we are learning—to apply learned rules or approaches in new circumstances or to new problems.

- One way to think about this in practical applications is that some moods are better for some tasks. A relatively negative mood is optimal for situations where we need to be focused on specific material and learning central aspects of that material.

- Some mild anxiety in studying for a test might actually enhance performance by focusing attention and ensuring that we study enough; this is especially true if the anxiety is not chronically present for us, but only there when we need to focus our studying.

- A relatively positive mood, by contrast, may be more useful for taking in new scenes, getting an overall feel for a new place (global focus of attention), creatively using past learning in the service of solving new problems, and other cases where the point of learning isn't for addressing a current, looming threat but for building up knowledge and resources for a longer-term perspective.

Suggested Reading

Fredrickson and Branigan, "Positive Emotions Broaden the Scope."

Nadler, Rabi, and Minda, "Better Mood and Better Performance."

Questions to Consider

1. Fear tends to focus our attention and enhance our learning for details relevant to a frightening experience—the weapon in an attacker's hand, for example. What might anger focus attention on, and what might anger tend to suppress attention toward? How would that influence what people learn?

2. Are positive emotions always good for learning? Are there some positive emotions that might, at least in your own experience, actually result in less learning?

Cultivating a Desire to Learn
Lecture 19

T hroughout this course, we have assumed that we have some reason to learn and focused on the process of learning without thinking much about the reason we learn something or whether the reason might matter for how and how well we learn something. How people feel about learning—whether they experience it as something they want to do or have to do—can vary quite a bit. In this lecture, we will consider how those motivations might influence learning material over time and how to foster the kinds of motivation that will help support learning rather than undermine it.

Self-Determination Theory
- Self-determination theory, which was developed by Richard Ryan and Edward Deci at the University of Rochester, is a broad theory of human motivation that focuses on the importance of autonomy for human flourishing in general and motivation in particular.

- In self-determination theory, we can think about our actions—including those involved in learning—as arrayed on a continuum from heteronymous to autonomous.

- Heteronymous actions are those that are controlled externally; they are actions that we experience as being required by external circumstance. On the other end of the spectrum are actions that are autonomous, which are things we choose freely for ourselves and without any coercion—usually, things that are consistent with our larger goals and identities.

- Within the continuum from heteronymous to autonomous are other types of actions, such as introjected actions, which are linked to external concerns about what other people want or need or about rules.

- An identified experience of an action means that you have decided to do something for reasons that may be rooted in external forces, but you have thought through the action and are doing it because you think the action is the right thing to do.

- Moving a step further along the continuum, you can connect this action to your overall sense of who you are and what your values are, making the action integrated rather than merely identified.

- Learning for heteronymous reasons can feel relatively bad, and it can undermine people's desire to continue learning about a topic over the long term. In fact, the more autonomy people report in all domains of life, the better they generally are doing in those domains.

- At least two aspects of a learning situation support autonomy: the ability to make meaningful choices about your learning and receiving informative feedback about your progress in learning.

- Anything that reminds us we are learning because of extrinsic forces might undermine autonomy, such as surveillance—being monitored and evaluated via exams and grades and, of course, being punished.

Rewards, Goals, and Learning
- The origins of self-determination theory were focused on the paradoxical effects of rewards on behavior. It turns out that rewards can really disrupt intrinsic motivation. Rewards may not give people intrinsic, autonomous reasons to do something—including to learn—so when the reward is gone, so is the behavior.

- Rewards are complicated. Rewards for learning are often performance based, including receiving good grades and being on the honor roll. As such, rewards simultaneously provide informative feedback about one's learning progress, which can be good for motivation.

- However, rewards also are external controls on behavior; they are offered to encourage us to behave in particular ways. As such, they are controlling and should undermine intrinsic motivation.

- Numerous studies have shown that people who will be rewarded for an activity later are less likely to choose that activity over other options. If they do choose that activity, they keep at it for shorter periods of time.

- As a consequence, when we reward people for learning with good grades or other types of tangible, material rewards, we are potentially undermining the extent to which they subsequently wish to learn about that topic—and the extent to which they will pursue that topic.

- Offering people positive verbal feedback, by contrast, enhances their autonomy and intrinsic motivation to do a task. However, it is critical that the feedback be offered in a noncontrolling way.

- Educational researcher Alfie Kohn has written about how praise can become controlling and can undermine motivation in insidious ways. However, we can be at least somewhat autonomously motivated by different aspects of learning.

- Researchers distinguish between learning goals and performance goals, and you could conceivably hold both types of goals in an autonomous way. Learning goals are about getting better and mastering a content area while performance goals are about demonstrating that knowledge.

- When researchers have looked at these types of goals and how they influence learning, performance goals often leave people vulnerable to losing motivation. If you hold a performance goal, you need to successfully achieve and demonstrate good performance to keep yourself motivated for longer periods of time. If you fail at a performance, your motivation to continue learning suffers.

- By contrast, when we are learning for the sake of learning, a performance failure may be disappointing, but it does not completely undermine our broader goal—and the broader goal of learning and improvement can sustain motivation in the face of failure.

Types of Theorists, Feedback, and Motivation

- Essentially, we can approach learning as a revelation of our underlying intelligence or as a process of changes that is incremental and ongoing. According to Carol Dweck and her collaborators, the majority of people fall into two groups: incremental theorists, who believe that we grow and change, and entity theorists, who believe that we are who we are.

- People can have incremental theories about personality, for example, while holding entity theories of intelligence. In addition, entity and incremental theorists are often equally capable, which means that differences in people's learning can be linked to differences in their underlying theories. Furthermore, there is evidence that intelligence is somewhat incremental—that it can increase given the right circumstances.

- In a review of over 100 studies, Deci and Ryan showed that positive information about performance enhances people's motivation. We all like doing what we think we're good at; if we're learning well, we like to keep learning.

- However, Dweck and her collaborators have focused on getting feedback about performance that is negative. They have focused on discovering what helps maintain motivation when you actually get feedback that says you are doing badly, and they have found that this depends on what theories you have about intelligence.

- If you are an entity theorist and you get feedback that you haven't learned something very well, you interpret that as indicating a lack of intelligence—the problem is your ability. If the problem is your ability, you lose motivation.

- If you are an incremental theorist, by contrast, you tend to interpret the negative feedback as signaling something about your effort or your strategies—but not something about your innate, nonchangeable ability. If you think the problem is effort or strategy, you have a golden opportunity for revitalizing motivation and trying again.

- Dweck and her colleagues find that incremental theorists cope better with a setback or initial failure and go on to do better long term than entity theorists—both in laboratory studies and in real-world learning contexts.

Revitalizing Motivation for Unpleasant Tasks
- Ryan and Deci's focus on how educators and parents can behave around necessary but disliked tasks in order to not undermine people's capacity to internalize the tasks, or intrinsically motivate.

- Some of the findings from this line of thinking suggest that we should avoid controlling language, create opportunities for meaningful choice whenever they are there, and be careful about praise and other forms of rewards. Lack of choice, excessive reliance on praise or praise delivered in a controlling way, and excessive supervision and monitoring can all delay or prohibit an individual's ability to internalize and to autonomously engage in learning.

- A second form for addressing this issue is how people themselves can regulate their experiences with learning in order to maximize their own intrinsic motivation. Work from this perspective is conducted by Carol Sansone and Judith Harackiewicz and their collaborators, who argue that intrinsic motivation is present whenever people do something because they find it interesting.

- This is consistent with Deci and Ryan's more intrinsic side of the continuum—that is, actions we find interesting to do are typically those in which we at a minimum find the task itself to be valuable because it will be interesting, and often they are things we feel at least somewhat autonomous about doing.

- From the self-determination theory perspective, however, a task might flip around on that autonomy-heteronomy continuum—sometimes feeling intrinsically motivated and sometimes feeling extrinsically motivated.

- Sansone, Harackiewicz, and their collaborators argue that we can actively move ourselves around on that continuum; we can turn play into work and work into play via strategies we employ.

- Consider two types of goals that often operate simultaneously in learning: a what goal, which is the activity itself, and a why goal, which is the purpose in doing the activity—and this could vary across different people.

Engaging in self-testing is a great way to create the circumstances that foster motivation in learning.

- When first engaging in an activity, you determine if you find it interesting. If you do, you probably continue doing it. If not, you have to figure out how to engage with the activity in a way that works for you or decide to stop doing it.

- One of the major findings emerging from this work is that a match between the experience and the why goals leads to stronger interest and more sustained engagement in an activity.

- In several studies, Sansone and her colleagues have looked at people whose why goals often include making social connections—people they describe as high in interpersonal orientation—and people whose why goals seldom involve relationships or connections to others.

- Sansone and her colleagues have found that if the context of learning matches the person's interpersonal goals, that is beneficial for motivation. In other words, social people like to learn with others while relatively less social people prefer to learn by themselves—and both types of people are motivated in those contexts.

- For our own learning experiences, we can try to create the circumstances that foster intrinsic, autonomous engagement with learning. That includes trying to structure learning so that we experience a sense of meaningful choice and trying to find ways for achieving meaningful feedback that is informative about our progress. This might include self-testing but also talking with others, which often results in gaining a clearer sense of what we do and do not understand.

- Additionally, cultivate a belief in incremental theories of intelligence and ability. This belief is consistent with a great deal of data, so this is not about delusion but rather about truly seeing how much people can improve their capabilities with practice and time, and it's about believing this is true of ourselves as well as of others.

Suggested Reading

Ryan and Deci, "Self-Regulation and the Problem of Human Autonomy."

Sansone and Smith, "Interest and Self-Regulation."

Questions to Consider

1. Given how much emphasis on external regulation characterizes most of our early school experiences, could current practices undermine the motivation for lifelong learning?

2. What are strategies people can employ to maintain interest when they encounter challenging material? How might these strategies vary as a function of differences among people?

Intelligence and Learning
Lecture 20

I n the last several lectures, we have been discussing principles about learning that apply to everyone. In the next section of the course, we will move from a consideration of general factors that relate to learning to a consideration of how different people might learn differently—with different capacities and preferences or with different motivations. To begin this segment, we're going to ask whether there are individual differences in the capacity for learning, and then we'll consider a controversial topic within and outside psychology—namely, intelligence.

Implicit Learning

- One general learning mechanism or set of mechanisms is an implicit, nonconscious capacity to monitor probabilities of events in our environment—what we have called system one. This learning mechanism has long been touted as one that doesn't differ much between people.

- This type of learning can be examined with artificial grammar learning and sequential reaction time tasks, and there are reliable individual differences in implicit learning as assessed by these tasks.

- In addition, performance on these types of tasks is unrelated to measures of general intelligence and to measures of working memory capacity or executive function. That is, implicit learning is a distinct individual difference.

- Furthermore, people whose processing speed is faster show higher implicit learning scores, and people perform better on foreign-language learning and mathematics when they are better at implicit learning.

- If people's performance on one occasion is not similar to their performance on another occasion, it is unclear how much individual differences in implicit learning can help us understand broader differences between people in learning. Furthermore, we don't know yet if we have one set of mental processes for implicit learning or multiple such processes—in which case, the sequential reaction time task assesses only one.

- However, individual differences in this type of learning are related to academic achievement—which is usually viewed in terms of explicit, deliberate attempts to learn material—and to the long-established approach to individual differences in learning capacity: intelligence.

- Intelligence may not be a great explanation of differences in learning, at least in the ways we measure it; implicit learning offers a potentially useful alternative idea for researchers to explore.

The History of IQ Tests
- We think of intelligence as the capacity for adaptive, successful problem solving. In its earliest history, French scientist Alfred Binet argued that human intelligence involved such abilities as memory, judgment, reasoning, and social understanding.

- An intelligence quotient, or IQ, is a measure of someone's intelligence that is based on a relatively limited examination of their ability to do certain types of problems, often under conditions of limited time—these are called IQ tests.

- Binet developed some of the earliest IQ tests in France to determine whether children were ready to start school or whether they should wait. Around the onset of World War I, IQ testing became a way to sort out the strengths and weaknesses of army recruits for various positions.

- Today's IQ tests generally measure two distinct but related capacities that are often termed fluid and crystallized intelligence. Fluid intelligence consists of tests of speed of information processing, and crystallized intelligence consists of measures of vocabulary and knowledge.

- After these initial military applications, IQ tests were more fully developed for widespread use. This included adapting them for groups that weren't literate or couldn't speak English, which led to using IQ tests to evaluate immigrants and a number of other dubious contexts.

- The use of IQ tests shifted from an evaluation of a person's readiness to learn to the idea that IQ is a static element of a person's capacities and not something that changes or can be improved.

- In fact, when we speak of IQ, many people now presume that we are born with IQ and that it is what makes learning easier or harder for some people than others. In other words, IQ is an aptitude or talent that makes it easier to learn. However, IQ is the innate potential and is distinct from learning.

- This is why the data showing that one or another group, on average, scores lower on IQ tests is so troubling. If we instead assumed that IQ was some temporary state related to readiness to learn, we might view that same type of finding as indicating the need for remedial programs or other solutions—rather than as a claim of a group's fundamental inferiority.

IQ, Learning, and Genetics
- Evidence for IQ as an ability that facilitates learning needs to show two things: that IQ predicts learning and that it is a stable aptitude of a person.

- IQ scores tend to predict learning pretty well. In many cases, people with higher IQ scores appear to learn and then perform at a higher level than those with lower IQ scores. This is consistent with the notion that IQ is the ability to learn and perform a variety of tasks.

- Additionally, IQ needs to be a stable aptitude of a person; otherwise, it could be argued that IQ doesn't reflect ability to learn but perhaps the person's current state of learning. In fact, IQ test scores are quite stable over time.

- Furthermore, IQ seems to be highly heritable, which means that identical twins show more similar IQ test scores than other siblings, and this is true even when they are reared in different homes. In a given environment, there may be genetically linked differences in IQ, but these differences are not independent of the environment.
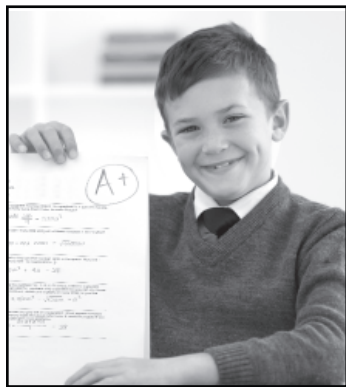
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IQ test scores tend to predict learning and are stable over time. In addition, IQ seems to be highly heritable.

- Under the assumption that intelligence is the capacity to learn and that it is genetic, researchers selectively bred rats who were either good or bad at maze learning. Rats from each strain were then reared under three different conditions: the usual laboratory conditions, impoverished conditions, and enriched conditions.

- Then, rats were tested under standard conditions. Researchers only recorded differences in the environment that the rats were typically bred and reared in. Under enriched conditions, both strains performed better, and they did equally well; under impoverished conditions, both strains performed worse, and they did equally poorly.

- Therefore, the effects of any gene—including any gene involved with intelligence—are intertwined with the environment so much that you can't separate them. In the case of IQ, this finding means that IQ may have to do with genetic effects but only in the way that specific genes are operating within a person's specific environment over time.

- The stability of IQ may not mean that IQ comes first and is genetically based and that learning relies on IQ; rather, the stability of IQ may mean that people who start out having learned more in their environment continue to have advantages over time because most people who start out having learned more maintain their environmental advantages or disadvantages—the circumstances that led them to learn more or less than their peers.

IQ Tests as Measurements of Achievement
- A psychologist named Steve Ceci argued that IQ tests are actually measuring achievement. In other words, IQ tests don't measure your ability to learn; instead, IQ tests measure what you have previously learned, which gives you an advantage on subsequent learning.

- In making his argument, Ceci found that the more school people attend (measured by the highest grade completed), the higher their IQ; this relationship remains strong even when controlling for potential confounding variables.

- In addition, during summer vacation, children's IQ scores drop, and over the school year, children's IQ scores rise. The summer drop is particularly bad for low-income children. This means that over the school year, as children learn more, their IQ scores increase. Over the summer, as they forget some of their newly learned material, IQ scores drop. This drop is worse in children whose summers are likely to involve less intellectual activity because their families are less able to afford stimulating summer camps and other academic experiences.

- Work on children who attend school only intermittently suggests that as they get older, their IQ declines steadily. Some of this work comes from historical studies of migrant workers and similar families in which younger children attend school regularly, but older children increasingly work rather than regularly attend school.

- Across a wide array of historical periods, people who delay beginning school because of war, lack of an available teacher, or segregation and racism lose a significant number of IQ points per year of delayed schooling.

- Similarly, people who drop out of school early, without finishing high school, also show IQ deficits. Furthermore, in the studies Ceci reviews, the relationship between IQ and dropping out is not nearly enough to explain the lower adult IQ of those who left school before the end of high school.

- If you look at effects of age on IQ independently of effects of schooling, which can be done by examining differently aged children within the same school grade, you find that a year of schooling has a larger effect on IQ scores than one year of development.

- Many historical shifts in IQ scores, such as large increases in IQ scores of World War II recruits compared to World War I recruits, can be attributed to historical expansions in the typical person's education.

- Finally, achievement tests, which purport to measure learning, are so identical to IQ tests that it is folly to think they are distinct. Not only are these two types of tests highly correlated, but they are also related to other variables—demographic variables such as socioeconomic status and factors such as years of schooling—in identical ways. In every way that has been examined, achievement tests and IQ tests seem to be measuring the same thing.

IQ and Schooling

- In his review, Ceci showed that schooling may affect basic cognitive capacities such as attention, perceptual abilities, memory, executive function—and IQ.

- Schools provide direct instruction on many elements tested in standard IQ tests. Schooling also provides children with instructions on strategies for thinking, such as ways of classifying items. Furthermore, school experiences give children skills at sitting still, decoding instructions, following adult directions, and other capacities that foster better IQ test performance.

- Ceci doesn't argue that IQ is meaningless or that schooling can make all children equally bright; rather, he suggests that IQ is better conceived of as a complex measure of achievement that indexes past learning, and past learning is a function of experiences provided to people over their lifetime—as well as whatever innate differences there might be in people's learning abilities.

- IQ is a fraught concept in our society in part because, historically, a test designed to help assess children's readiness for schooling became linked to ideas about ingrained and unchangeable mental superiority and inferiority, the inequality of individuals and groups, and the justification of social inequities.

- From Ceci's point of view, increasing intelligence involves the goal of promoting and supporting learning as the route to promote intelligence, and this means supporting the basic biologically healthy state that gives children a foundation for learning as well as supporting access to education for everyone.

Suggested Reading

Ceci, "How Much Does Schooling Influence General Intelligence?"

Kaufman, DeYoun, Gray, Jimenez, Brown, and Mackintosh, "Implicit Learning as an Ability."

1. Implicit learning ability seems to be related to intuition. How might the capacity to learn patterns without awareness relate to intuition?

2. Traditional IQ tests focus heavily on information processing and knowledge of vocabulary. What are other aspects of intelligence that might be poorly captured by such tests but that might be relevant to learning?

Are Learning Styles Real?
Lecture 21

Intelligence has been viewed as a capacity for learning, but it increasingly seems like it might reflect people's learning history rather than their ability to learn in the future. Additionally, individual differences in implicit learning remain consistent with the idea that some people are simply better than others at learning in general. In this lecture, we'll consider two overlapping ideas that are more optimistic: We're all good at some things but not others, and we may all differ in the way we like to learn. These ideas are, respectively, the notions of multiple intelligences and learning styles.

Multiple Intelligences
- The idea of multiple intelligences was initially proposed by Howard Gardner several decades ago. From Gardner's view, the nature of an intelligence depends in part on the type of information that it is being used to process.

- In contrast to the types of abilities measured on IQ tests, Gardner argued that people actually demonstrate intelligence in what is called a domain-specific way. Because of this, in our focus on IQ, we ignore many ways in which people could demonstrate intelligence.

- Initially, Gardner proposed seven types of intelligence.

  - Logical-mathematical intelligence is one of the types of intelligence assessed by IQ tests. This intelligence is what contributes to various types of reasoning and mathematical computation.

  - Spatial intelligence is another type of intelligence that is partially captured by IQ tests, and it has to do with people's understanding of space.

- ○ Verbal intelligence allows people to play with words, make elegant and persuasive arguments, understand and make inferences from what they read, and is also measured on IQ tests.

- ○ Interpersonal intelligences involve the ability to navigate relationships and social interactions with skill.

- ○ Musical intelligence involves great abilities in melody and rhythm.

- ○ Kinesthetic intelligence involves capacities for movement.

- ○ Intrapersonal intelligence refers to the ability to be aware of one's own feelings, motivations, and thoughts.

- More recently, Gardner proposed that there might be additional intelligences—having to do with spirituality and with nature and natural systems—but he cautions about the relatively little evidence on these new types of intelligence as of yet.

- To demonstrate the intelligences, we need evidence that the different intelligences are, in fact, separate from one another. However, for many of Gardner's proposed intelligences, there are no easily administered tests.

- For standard IQ tests, we can measure logical-mathematical, spatial, and verbal. In many cases where it has been possible to measure, the relationships among two intelligences fall in a gray area; these tests suggest that the intelligences are related but are not quite the same.

- In the rare cases where more intensive assessments of ability have been made, such as observing actual job performance, these measurements are often highly correlated with IQ tests.

- Therefore, researchers in favor of the idea of a single intelligence view the evidence as indicating Gardner is wrong and that all intelligences are related whereas Gardner and his supporters view the evidence in precisely the opposite way. This is an example of confirmation bias.

Multiple Intelligences and Learning

- Across a large number of studies, Tim Hoeffler found that higher spatial intelligence is associated with better learning from visualizations. Therefore, people who score higher on spatial IQ tests who are then presented with pictures learn more from the pictures than those whose spatial IQ scores were lower. However, it matters what types of visual images you are trying to learn from.

- Hoeffler also found that this was most evident when the visual images were static and learners had to use their own minds to rotate the diagram or imagine how a process unfolded from the starting point that was depicted. When the images were made dynamic, people with lower visual ability were able to benefit from visualization also.

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Experts, including chess players, process new expertise-related information differently than novices.

- For spatial intelligence, it looks like learning from visualization is easier for those with higher spatial ability, but does this mean that there are different intelligences—or does it really mean that people who are more experienced in visualization, as indicated by higher visual ability tests, do better at learning from visualization?

- As with standard IQ, is it possible that these intelligences reflect not some type of pure ability but really expertise? It is very difficult to disentangle these two issues—a priori ability versus more experience.

- In both cases, experience and prior learning give someone an advantage in learning something new. Therefore, the findings regarding spatial intelligence and learning from visualizations hold, but we are interpreting them differently—as differences in existing knowledge that influence the ease of future learning.

- While there are relatively few studies looking at multiple intelligences and learning, there are many studies that show that experts process new expertise-relevant information quite differently than novices.

Multiple Intelligences versus Learning Styles
- While Gardner himself focused primarily on the concept of intelligences, many educators seized on his ideas as relevant to differences in learning styles, and the idea that we have different learning styles is enormously prevalent in today's world.

- Learning styles are distinct from the idea of multiple intelligences because they are presumed to reflect differences in the way people learn rather than in abilities.

- As of 2004, there were 170 different models and measures of learning styles. One example of learning styles includes the V.A.K. category system, in which people may be either visual, auditory, or kinesthetic learners.

- To begin with, learning styles are real: There are reliable, measureable differences in people's preferences for learning, and these can be measured and described with most of those 170 different systems.

- Some people think better when moving while others need to be still. Many people need to build things to see how they work while others would rather look at diagrams or listen to a lecture about a structure.

- These preferences are stable over time—that is, you won't change your mind about being an auditory learner over a period of a few months, but over decades, things can shift. Furthermore, these preferences will tell you something about how you might choose to learn.

- Does this mean learning styles or learning preferences matter for actual learning? In terms of learning, we know that elaborative encoding is a very useful and helpful aid in learning, and we know that most things we learn involve integrating across many areas of the brain. Moreover, we know that prior knowledge and expertise matter enormously in learning.

- All of this suggests that adapting material to a preference for visual stimuli by excluding auditory information, for example, doesn't make sense. It would result in less elaborative encoding because you have reduced one arena for the development of connections—an arena where there could be prior knowledge and experience that would facilitate learning, for example.

- We also know that what people choose to do—their preferences for strategies, in that case—doesn't always correlate with what they should do to maximize learning.

- The core issue is that these preferences for different ways of learning do not seem to matter, in the sense that adapting teaching or learning contexts to the preferences of the individual results in better learning—faster-acquired or better-retained learning.

- The learning styles hypothesis has three components.

    ○ People will learn better with one approach than with another.

    ○ The approach that is best will differ for different people because, otherwise, we aren't talking about styles and individual differences but about metacognition and learning strategies that work for everyone, such as repeated testing.

    ○ Most importantly, people will learn best when they are taught in a way that matches their learning style.

- To fully test this hypothesis, researchers need to conduct studies in which learning styles are identified, and within each learning style, people get randomly assigned to an instruction that either matches or doesn't match their preferred style. After instruction, all participants are evaluated for their learning with the same test.

- A comprehensive literature review by several prominent psychologists found a small number of studies that actually tested the learning styles hypothesis in this way.

- One study looked at learning of computer-presented information about electronics and visual or verbal learning styles assessed in several different ways. Across variations of the study and many different ways of classifying people as visual or verbal learners, the researchers found no evidence that people should receive information matched to their learning style in order to optimize learning.

- Only one study supported the idea of learning styles, and that particular study had some strange features—such as the use of unusual methods for assessing learning outcomes—that make it less than ideal evidence.

- Overall, multimodal presentation works better than matching learning styles for most people. Additionally, visual presentations can be very strong for learning in general, but our expertise, or prior learning, about how to use visualizations matters in this regard.

Implications of Learning Styles
- For those that have more prior knowledge, more knowledge is acquired and with greater ease. One way to think about this phenomenon is that this is the core of specialization in a complex society—that is, it's acceptable for people to differ in their experiences, expertise, and subsequent learning.

- The same psychologists who reviewed research on learning styles and suggested that there wasn't much evidence for attending to them admitted that there are enormous implications for learning of differences in prior knowledge.

- Instead of looking at multiple intelligences or learning styles as an opportunity to fix the way we educate people, researchers interested in enhancing learning might focus on how we can assess individual differences in prior knowledge and how we can make use of that information to tailor education to what people do know and where they need to learn more.

- More advanced and knowledgeable people may be better able to benefit from discovery-based learning than truly novice learners. This is consistent with the fact that discovery-based learning, in its moderate forms, works better in adulthood than earlier in the lifespan.

- This possibility is also consistent with findings that more advanced learners benefit from having less structure—that is, less teacher-directed, explicit guidance—while less advanced learners, or those with less prior knowledge, benefit from having more teacher direction and explicit guidance.

- In addition, understanding what assumptions learners bring into their learning can be helpful for shaping the way that instruction unfolds. When we discussed work on scientific understandings by Michelene Chi, we talked about the process of learning as a change in models, and that change is easiest to support for learners if we know what their starting models are.

- Furthermore, all people may benefit from knowing more about metacognition—the things that can distort our understanding of our own learning and the strategies that are effective but unused by learners.

- Where learning styles may need to be retained as an idea is in the area of motivation because while learning in one's preferred style may not have anything to do with learning outcomes, if it affects people's interests and motivations, it may still be a useful concept.

Suggested Reading

Geake, "Neuromythologies in Education."

Pashler, McDaniel, Rohrer, and Bjork, "Learning Styles."

Schaler, ed., *Howard Gardner under Fire*.

Questions to Consider

1. A different way to take the idea of multiple intelligences seriously is to view them as indicating acquired expertise. If we view them this way, what would the implications for teaching and learning be?

2. Given the absolute paucity of evidence on learning styles, what do you think accounts for their enormous popularity? Given the evidence, can you give up on a belief in learning styles? Why or why not?

Different People, Different Interests
Lecture 22

T hus far, we have focused on whether individual differences in abilities or learning preferences are related to individual differences in learning, and we have continued to encounter the importance of individual differences in prior learning. In this lecture, we'll analyze the issue of motivation—but from the perspective of individual differences—from the standpoint of interest. That is, are there individual differences in what people find interesting? If so, do those differences affect learning? Then, we'll consider a personality trait that might be interpreted in terms of general interest in learning—openness to experience—and how it affects learning.

Interests and Learning

- In fact, there are differences among people in what they find interesting, and these differences are evident very early in our lives. Furthermore, it seems very likely that these differences influence learning.

- We all make choices about the activities we do and the topics we seek information about, and when it comes to leisure, what drives our choices is interest. Because interest is shaping our attention and actions, and over time, our knowledge, it should influence learning.

- It would be important to know whether interest shapes learning because from an educational standpoint, it means that you need to devote time to making your topic interesting—as well as clear and understandable.

- To test the effect of interests on learning requires creating similar learning materials that reflect or relate to different interests and exposing each person to materials that are consonant with his or her interests—and materials that are not. In addition, if you don't make the materials similar and you find learning differences, you can't tell whether it was the materials or the people. Furthermore, researchers have to ensure that these comparisons involve items that are in general of similar interest.

- In a project conducted by K. Ann Renninger and her colleagues, preschool children were shown pictures of their interest objects and other objects. The other objects reflected the interests of other children, which implies that the object is not fundamentally boring. The researchers examined the direction of children's gaze to evaluate their attentional focus and were able to show that children were more likely to look at their interest objects than at the other objects.

- Children also showed biases in recognition and recall of images they were shown in other parts of this study toward their individual, idiosyncratic interests. Shifting attention and differences in memory suggest that interests will also influence learning—at least in three- to four-year-old children.

- This type of research becomes more interesting and more important when we start looking at required learning in older children or adults, such as reading comprehension or math, and whether tailoring that learning to individual interests is helpful.

- More recently, Renninger and her colleagues conducted this type of work with 11-year-old children and looked more explicitly at learning from texts and at solving word problems in math.

- As in the preschooler study, they initially sought to identify children's idiosyncratic interests. Then, the researchers developed reading and math materials that incorporated children's interests and examined whether children learned better when the text concerned material in which they were interested.

- They found that when students are allowed to work on tasks related to their individual interests, their learning is sometimes enhanced. This is more true for reading than for math problems. However, interests sometimes masked students' comprehension difficulties, so they were less aware of gaps in their understanding.

- This research suggests that tailoring educational materials to individual interests is something worth examining with caution because it's pretty difficult to do it well, and it may not pay off all that well for how much children learn—though it may help keep children motivated.

Differences in Interests
- Theorists have developed a model that linearly describes the process of how people develop interests: First, people may experience what is called a triggered situational interest, which is a momentary experience of the emotion of interest that is triggered by some ongoing event. Then, people either maintain that situational interest or lose it.

- Maintained situational interests are not yet part of a person's identity, but they result in repeated experiences of interest. Researchers refer to a third stage that involves actively seeking out engagement as an emerging individual interest, which is an interest that is sufficiently part of a person's sense of self that it motivates his or her choices of situations and behaviors.

- Over time, individual interests can become sustained—perhaps over a lifetime. By the time you have a developed or sustained individual interest, you also have substantial competence in that area.

- From self-determination theory, we learned of our need to be autonomous—to control and direct our own lives—and how learning experiences that undermine autonomy have serious costs. Self-determination theory proposes that there are three fundamental needs humans have: Autonomy is one, but two others are to connect with others and to feel competent.

- In terms of what types of things trigger situational interests and maintain situational interests—an important precursor for interests getting to be part of our sense of ourselves—it may not be surprising that self-initiation, perceiving oneself as talented or potentially talented, and feeling connected to other people are part of the triggering of initial interest.

- In other words, an activity or topic seems interesting to us initially when engaging with that topic, or activity fuels autonomy, competence, or relatedness.

- When we take a long-term perspective and look at how those situationally triggered interests might be sustained and turned into individually owned interests, social support, which refers to the role other people play in fostering our interests, turns out to matter.

- In many of the studies on social support, the other people are parents and teachers. Parents support interests financially in the way of time and resources for a pursuit and by showing interest and enthusiasm. These actions show people that their emerging interests is valued and allows them to increase their competence within the interest area.

- Teachers who provide clear structure and monitoring also help students develop interests; structure and monitoring are ways to help students acquire competence, and monitoring in particular communicates the value of competence.

- Longitudinal studies of students' interests in academic contexts point to self-perceived competence as a major foundation for the development, maintenance, and enhancement of individual interests over time. In other words, interests were relevant to students' course selections, but over time, achievement was a far stronger predictor of future interest than was initial interest.

- Therefore, interests matter, but they tend to matter more in terms of how they catalyze expertise. That is, the way individual interests appear to play out long term is via fostering initial learning, which in turn catalyzes greater interest and greater subsequent learning. Furthermore, competence itself is fundamental to interest; we like what we feel good at.

- Thus far, we've emphasized prior knowledge as making learning easier because encoding things is easier when you can more easily make connections between new knowledge and what you already know. However, prior knowledge can also make it feel more interesting to learn something, perhaps because the learning experience is more likely to feed your needs for competence.

Differences in Openness to Experience
- Researchers in personality have arrived at a consensus that personality is best described in five or six broad dimensions. One of these is central to the idea of individual differences in interest, and that is the dimension of openness to experience.

- People vary in the extent to which they are high or low in openness to experience. Those who are high on this trait welcome novelty, find aesthetic experiences like looking at art and architecture to be interesting, enjoy reading and learning about new things, and enjoy thinking about the meanings of what they experience.

- This is a trait that captures a general orientation toward intellectual, learning, creative, and aesthetic pursuits, and people do vary on this dimension—with some people wanting to do more exploring, thinking, and learning and others wanting less. Broadly, this can be thought of as a difference in the interest in learning.

- Like other personality traits, openness to experience is largely stable after early adulthood—by about age 30. Being high on openness to experience appears to have important advantages in people's ability to experience an array of feelings without trying to suppress them or distance from them and in the way people deal with stressful experiences.

- Openness to experience could be linked to better learning in at least two distinct ways. First, openness could work indirectly, by simply being related to people pursuing more learning—after all, it is an individual difference in interest in learning.

- Small differences in interests lead to larger differences in acquired knowledge, which in turn lead to larger and larger differences in subsequent learning. Likewise, openness could motivate people to seek further education, which in turn increases learning.

- In addition, openness might work directly, by changing the way people engage with the same learning experience.

- Some studies examine relationships between openness to experience and various types of cognitive performance tests, including tests of general knowledge. Basically, these tests are indirect evidence for the idea that openness to experience fosters seeking out more learning opportunities because such cognitive performance tests suggest a history of learning in various areas.

Personality and Learning
- Across many studies, openness to experience is consistently linked to knowledge-based aspects of IQ test performance. However, these are somewhat unsatisfying as tests of whether openness differences influence learning because a much more controlled approach would be needed in which people who differ in openness to experience all try to learn the same material under the same circumstances.

- In one project, researchers looked at a pilot training program, which was interesting for several reasons. First, it had two stages—computer simulation and actual cockpit training—so it permitted the researchers to look at how traits like openness predict the transfer of initial learning to a new phase of learning, with different demands. In addition, it standardized what people had to learn. Furthermore, the training is a kind of learning that isn't stereotypically intellectual, so it makes for a harder test.

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Research on pilot training programs shows that being more open to experience fosters general learning and is linked to a better ability to transfer learning.

- While both phases of training involve similar actions, they involve them under quite different circumstances with different levels of seriousness and risk.

- Before people began the program, they reported on their personality—specifically on openness to experience, emotional stability, and conscientiousness. For phase one learning, none of these traits were relevant to how well people performed and how quickly they mastered that phase.

- For phase two learning, one major predictor of how people did was phase one learning. However, personality also mattered: The higher someone's openness to experience, the more quickly they learned in phase two.

- Therefore, there is some evidence that being more open to experience fosters general learning and is linked to better ability to transfer learning from one context—a computer simulator—to another.

Suggested Reading

Herold, Davis, Fedor, and Parsons, "Dispositional Influences on Transfer of Learning."

Hofer, "Adolescents' Development of Individual Interests."

Questions to Consider

1. If competence plays a role in interest, how can people develop interests in areas where they are initially not so competent? What strategies could be useful in mitigating the role of early inability in a learning process?

2. Could you cultivate greater openness in personality?

Learning across the Lifespan
Lecture 23

This section of the course has been focused on individual differences relevant to learning, and we've emphasized abilities and interests. In the last lecture, we learned that people differ in their interests and that it does influence learning. People also differ by age, and we've hinted at the role of age differences in learning throughout the course. In this lecture, we're going to centrally focus on the role of age as an individual difference that affects learning—in part through its impact on cognitive abilities and on motivation.

Age-Related Differences in Information-Processing Abilities

- Across the entire course, there are a few principles that will serve as an introduction for thinking about how learning might differ at different ages.

- The first principle is that development is not learning because development happens in similar ways for all healthy individuals with relatively little dependence on experience beyond the minimal typical environment.

- The second principle is that learning relies on information processing and associated abilities. Those abilities mature, and they can take a while to do so. At ages when those abilities are not mature, they actually limit some of what children can learn.

- Furthermore, those abilities also decline in adulthood. That is, as people age, they become less able to juggle information in working memory and less able to engage executive functions to inhibit distractions.

- In the case of childhood and old age, there is increasing evidence that the rise and fall of basic information-processing abilities is biological based—rooted in changes in the brain.

- Together, the first and second principles point to a very important issue about age differences in learning: Developmental differences in information-processing abilities constrain or enable more effective learning at different points in the lifespan.

- Young children's learning is constrained by their relatively immature cognitive abilities. Elderly adults' learning is constrained, even among healthy older adults, by age-related deficits in those same cognitive skills.

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- There is a wealth of research on older adults' verbal learning and other kinds of explicit, deliberate learning tasks, such as learning lists of words. Virtually all of this work shows that older adults perform more poorly, on average, than young adults.

Older adults have somewhat reduced information-processing abilities, making a broad search for new information a more difficult task than for younger adults.

- In an important study of this phenomenon, Paul Baltes and his colleagues attempted to look at verbal learning in a way that tested the limits of older adults' performance. The first conclusion from this study was that older adults were capable of learning a new strategy for learning word lists and employing that strategy.

- Another conclusion is that older adults benefitted enormously from the new strategy as compared to their initial ability to learn the words. However, the best of the older adults were well below the worst of the younger adults.

- In this study, age-related, biologically based changes in basic information-processing capacities limited learning performance—even when strategies and expertise were matched.

- Older adults' more implicit learning processes appear relatively preserved from any changes relative to capacities like those for working memory and executive function.

- It is not clear whether implicit learning processes are a single mechanism or many different nonconscious mechanisms; in the latter case, many of these mechanisms could be adversely affected by aging.

- For reading, for typically developing children, children of the same age with higher working memory capacity show higher reading performance because reading draws heavily on the ability to hold items in mind and put them together to understand texts.

- Therefore, even though children may be equally good at recognizing phonemes and decoding individual words, if they are developmentally behind or ahead in working memory capacity, it will affect the speed with which they can learn to read.

- Additionally, we think of children as excellent learners despite their cognitive limitations, so the fact that there are cognitive limitations associated with aging, too, doesn't mean we should be pessimistic about the possibilities of truly lifelong learning.

Age-Related Differences in Prior Knowledge
- The third principle we will examine is that prior knowledge matters. Different age groups have different levels of prior knowledge on which to draw when learning new things. Mostly, it is helpful to have more prior knowledge, but it can sometimes be a problem for people because if prior knowledge is incorrect or leads us astray, we sometimes fail to incorporate information into our existing beliefs and ideas.

- If we take aspects of IQ like vocabulary and general knowledge as reflecting acquired learning over time, studies tend to show that the older the research participant, the higher, on average, their scores on these types of IQ measures.

- Longitudinal studies also show growth in these types of assessments into old age. In fact, we don't really begin to decline in any meaningful fashion until after age 70. As we get older, we know more, and that means we could have more prior knowledge on which to draw in learning; we are particularly likely to know ourselves better.

- One interesting place where this age advantage in prior knowledge might play a role is in allowing older adults, as compared with younger adults, to make more efficient decisions—decisions that require less information but that are equally good.

- This is especially important given that older adults have somewhat reduced information-processing abilities, making a broad search for new information a more difficult task.

- Decision-making studies often look at occasions in which people have to choose between two or more alternatives and are able to search available information to help them choose. The decisions examined range from relatively controlled, artificial choices presented to people in a laboratory to real-world, significant choices, such as breast cancer treatment choices by patients.

- A recent examination looked at studies of older adults' decision making across different studies of consumer choice, which falls somewhere in between those extremes because it includes real-world decisions with consequences but ranges from trivial choices among everyday products to medical choices about treatments.

- Overall, this review suggested that older adults consider less information than do young adults on average. These authors also detected that the differences in the information search of age groups weren't the same in all studies.

- When they examined why this might be, they found that older adults' information search was most similar to younger adults' information search in the context of health decisions and was most different in nonhealth domains. This may have to do with motivational issues.

- Less information could be good or bad: If the result is that older adults make poorer decisions, then less information is bad, but if the decisions reached by older and younger adults are similar in quality, then less information is good—it's about efficiency. The idea is that prior knowledge might reduce the need for information searching, resulting in equivalent decision quality.

Age-Related Differences in Motivation and Interest
- The fourth principle is that motivation and interest matters, and motivation also varies over the lifespan in ways that are importantly connected to learning.

- Generally, openness to experience declines in later life, and this decline is found longitudinally, when we compare individuals to themselves earlier in their lives. It is also found cross sectionally, when we compare people of one age to others of different ages. This pattern has also been found in virtually every country that has been studied.

- That general age-based change suggests that as we age, we may be less interested in learning new things in general, and that is consistent with decision-making research.

- A well-established perspective on adulthood and aging, selectivity theory, suggests that we are going to be motivated by different aspects of our worlds as we approach the end of life.

- Laura Carstensen and her collaborators argue that we have at least two major motives as we go about our daily lives: One is an information-seeking motive, or curiosity drive, and the other is an emotion-regulation motive. Respectively, these can be encapsulated as finding out and feeling good.

- Carstensen points out, however, that the availability of information and its general utility to us may diminish over adulthood as we become older because we tend to know more as we get older, meaning that there is less to learn.

- Additionally, the available new information in the world is of less utility and relevance to us as we get older for two reasons. First, when we have established our lives, we often know the information and skills we need for living our lives, so remaining things to learn are less necessary. In addition, information often has more long-term payoffs. As people approach the end of life, they may be less interested in pursuing things that don't have immediate rewards.

- Emotion in terms of feeling good has immediate rewards. Carstensen has shown in several studies that as people get older, their relative emphasis on new information versus feeling good shifts, and emotion becomes more important and more salient.

- Socioemotional selectivity theory has spawned a wide range of investigations, including explorations of social activity, personality change, preferences for products, and everyday emotional experience. However, the more pertinent issue is the effect of shifting motives on learning.

- A relative shift in concerns for emotion regulation over adulthood appears to change people's ways of paying attention to new information, learning that information—as reflected in memory—and even the way their brain responds to that information.

- Age-related differences in attention, learning, and memory have been labeled the positivity effect, which is an effect in which older adults, relative to younger adults, pay more attention to emotionally relevant stimuli—especially positive ones. They learn them more effectively and recall them better.

- The positivity effect has been shown with pictures, words, texts, and autobiographical memories and with measures of attention, retention, and even brain-based responding.

- The fact that positive and emotionally relevant information draws more attention from older adults can actually make up for some age-related losses.

- Adolescents, by contrast to older adults, are highly motivated by information. This is in part reflected by a phenomenon known as the reminiscence bump, in which our learning of songs, news events, TV shows, movies, and the events of our own lives is enhanced during adolescence.

Preserving Information-Processing Abilities
- Pursuing the following actions can preserve our ability to learn, although there are never guarantees that research findings about people on average will work for all individuals.

- The same actions that preserve information-processing abilities also contribute to other aspects of living a long and healthy—not to mention happy—life.

- Get some exercise. Both cardiovascular and strength training exercises appear to help preserve information-processing abilities, probably by enhancing blood flow in and outside the brain.

- Keep mentally active in meaningful ways. Examples of this include continuing education, traveling, volunteering efforts, and community involvement.

- It may be useful to try to learn something truly new every so often—something that is radically different from the usual things you do but that is still meaningful and enjoyable. Try a new dance class or sculpture course, or learn a new language.

Suggested Reading

Hertzog, Kramer, Wilson, and Lindenberger, "Enrichment Effects on Adult Cognitive Development."

Questions to Consider

1. What do you think makes individuals who are higher in openness to experience and still seek new information even in later life different from the averages reported in this lecture?

2. Given greater prior knowledge in older adulthood, decision making might become more efficient—at least under some circumstances—but could prior knowledge also distort or make decision making problematic?

Making the Most of How We Learn
Lecture 24

I n this final lecture, we will begin by reviewing what we have learned with a special focus on how to optimize learning in everyday life. Additionally, we will expand our consideration of learning in two ways. First, we will consider the role of teachers, coaches, and other people in learning. Then, we will consider the frontiers of learning research—the questions that seem still unanswered and some of the exciting developments that are on the horizon for learning.

Optimizing Learning

- In this final lecture, we're going to revisit ways of optimizing learning with a special focus on two different second-language learning situations: In the first, you are learning a second language for fun, and in the second, you are a refugee—a stranger in a strange land—with a vital need to learn to communicate.

- Elaborative encoding involves linking what you learn to other things, making connections across different aspects of your experiences.

- If you are learning a language, you will do better if you both hear and see the words when learning them. Repeating them after hearing and seeing them helps, and so does visualizing objects or actions for nouns and verbs.

- The refugee, in the new country, is surrounded by the new language—both hearing and seeing words and having many chances to visualize. Second-language courses offer these opportunities in more formal ways.

- Space your learning: Take breaks between learning episodes and use sleep to enhance learning.

- Don't try to learn vocabulary two days before a trip; start early and work in chunks with breaks.

- For the refugee, this part is complicated. Because so much is new, it is difficult to have breaks between learning, and one of the only breaks available from language learning can be spending time with family and others from one's home country and speaking in one's native language.

- Making your learning variable involves learning in different situations so that your ability to use what you have learned is enhanced.

- Looking at vocabulary words in books, news articles, and menus will help make your practice of those words variable.

- This is an area where refugees and immigrants have an advantage in language learning; they will necessarily encounter the new language in many different settings and in many different ways. They have to use the language to accomplish basic tasks.

- In the latter part of the course, we have also learned that metacognition expands what we think of as effective rehearsals, which involve both what we know and what we are still working on learning.

- For those learning a second language in our home country, don't stop practicing vocabulary words you think you've learned—you still want to rehearse now and then.

- Refugees don't have trouble with this; the vocabulary they acquire will get used as they go about the business of their new lives.

- However, there is a dilemma for any newcomer to a strange country: Once you acquire a basic, functional ability in the language, you need to work to keep adding new vocabulary and new capacities rather than letting yourself make do with what you know well.

- Finally, we have discussed that a good rehearsal sometimes means giving yourself a test.

- As a second-language learner yourself, don't just read over the materials; you need to test yourself. Produce your vocabulary words without any cues, and then see how you did. Trying to talk is even more effective.

- In this case, the refugee has the advantage again because the situation requires talk tests all the time, which is exhausting but will end up producing better learning.

- We discussed the fact that prior knowledge matters a lot for future learning. Know what your prior knowledge is and how it might be used for and against effective learning.

- To learn a new language requires temporarily inhibiting the old one, so prior knowledge of the native language can get in the way, and the native language—for both you and the refugee—has probably made it more difficult to speak the new one.

- Additionally, if the refugee is illiterate, then he or she lacks the prior knowledge that literacy provides, and literacy helps with learning a new language. As we learn new languages, in fact, we learn them both by looking at words in print and hearing them spoken. We use our literacy to more quickly acquire parts of a new language.

- The refugee, however, has advantages when it comes to inhibiting the native language. If you are in your home country, you will have a difficult time doing that. If, as refugees, you are in a place where most people don't speak your language, that inhibition task is easier.

- Let system one work on your behalf when possible. Especially as adults, we overemphasize that rational, deliberate, conscious set of processes in learning and often fail to capitalize on system one's potential to help us.

- Simply playing books in the language you are trying to learn in the background, without focusing attention on them may help you learn rhythms and grammar rules in that language—and that may be another reason why immersion is so helpful for second-language learning.

- Hone, enhance, and maintain basic cognitive abilities for attention, working memory, and executive function. Executive function is going to be key to overcoming confirmation biases and using scientific reasoning to learn well.

- Learning a new language is helped by good executive function, and learning a language in turn may help executive function improve; given that this is true for learning of all different types of languages, both you and the refugee can benefit from second-language learning efforts.

- Capitalize on your metacognitive knowledge. Remember that there is an increase in variability of performance before acquiring a new level of skill. When learning, a bad practice day with a lot of mistakes sometimes is followed by better performance.

- For language learning, this translates directly into grammatical mistakes and accent horrors perhaps before acquiring a new level of proficiency. Knowing this can help people through the more difficult moments in language acquisition.

- Capitalize on what you know about motivation and interest development. One of the major conclusions from the latter half of this course is that we are generally motivated to attain competence, and competence motivates interest.

- In other words, if we can struggle through the initial phases of learning something, we may be in a better position to find it interesting. This is especially important when we have to learn something rather than choosing it freely because feeling that you have to learn something violates the need for autonomy.

- Finally, find a way to return some autonomy to the experience by making choices and engaging your creative juices in figuring out how you'll learn the language.

- For the refugee, this is another area where there are serious disadvantages; learning the new language is not a choice, and it is often a source of experiencing no sense of competence. However, many refugees do describe having chosen the country to which they're relocated, and thinking of their situation this way may be very helpful to preserve autonomy about learning that specific language.

The Role of Others in Learning
- Teachers include coaches, parents, and even friends. Teaching needs to be attentive to the way learning is affected by prior knowledge. Effective teachers have a clear sense of what students usually think at the beginning of a class and know how they can change that model toward one more consistent with the available knowledge in a field.

- Teaching needs to be attentive to the constructive nature of learning. For example, inquiry-based learning isn't always a great option for learners. However, lectures, although they are widely criticized, turn out to be efficient ways of helping people learn.

- Finally, good teaching also needs to be sensitive to motivational and metacognitive aspects of learning, and there are many reasons to believe that teaching situations vary in their capacity to do this effectively.

- Teachers often create external rewards for children, but research suggests that such rewards are risky and might further undermine motivation, making learning in those contexts feel coerced and externally controlled.

- For younger children, the work of Deanna Kuhn and others suggests that maturation of executive function, which develops into early adulthood, constrains how well people can think about or reflect on the process of learning. Adults don't do this very well, and children are even less capable of it and need more help. Therefore, we may need to think about how teaching, in various settings, can incorporate some metacognition.

Emerging Areas in Learning Research
- Neuroscience deals with the way our brains enable us to learn, remember, and do anything we do. Neuroscience shows that the brain is highly integrated and highly plastic, or changeable.

- What that means is that we use all our brains all the time, and that is important for thinking about learning because it gives an optimistic picture about the possibility of linking system one and system two processes. The plasticity of the brain also can be interpreted as support for lifelong learning.

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Technological developments in brain imaging and related research methods have led to an explosion in our ability to assess how the brain learns.

- The rise of virtual reality and high-fidelity simulators is another emerging area in learning research. Some of the most interesting examples are in medicine, in which book training and videos can only take people so far. However, virtual reality gives us a way to train doctors and nurses on virtual patients in ways that come very close to real experience.

- Virtual reality and high-fidelity simulators are also important tools for studying learning; they are allowing cutting-edge investigations such as how visual perspective changes our models of a space.

- Finally, computers are playing an increasing role in helping researchers test ideas about how we learn. In this work, researchers study human learning, develop an idea about how we learn, program a computer to follow that idea, and then see if the computer responds like a person.

- In other words, we don't learn like computers, but we might be able to program computers to learn like us—and use that ability to test ideas about how we learn.

Suggested Reading

Moreno and Mayer, "Personalized Messages That Promote Science Learning."

Questions to Consider

1. Imagine how you can employ the principles from this course in some learning you want to do—or even in some learning you have to do.

2. How—and at what age—might teachers better incorporate metacognitive strategies into the classroom context?

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