7a | Introduction to Concepts and Categorization

We're going to begin this module by discussing some of the key definitions that you'll need to understand in order to grasp the remaining material of this section. Then we're going to talk about a couple of examples of categorization in the real world. Specifically, we're going to look at medical diagnoses and selecting a major in university. Then we're going to talk about the classical view of categorization, and some problems with this classical view.

So, first let's look at a couple definitions. So, what is a concept? Well, a concept is a mental representation of some object, event, or pattern that has stored in it much of the knowledge typically thought relevant to that object, event, or pattern. So, any piece of factual knowledge that you have stored, any sort of object that you know anything about – that is a concept. Think about, for example, a Ferrari. Well, if you know what a Ferrari is, you know that it's a car, you know that it's fast, you know that it's Italian, and you know that it's expensive. All those attributes stored together with that object is what we can think of as a concept. As another example of a concept – and I might be dating myself here a little bit – but think about grunge music. Well, if you know anything about grunge music, you know that it started in Seattle, you know that it was a heavier style of music, and it contained bands such as Nirvana, Pearl Jam, and Soundgarden. All that information, again, is stored together in what your concept of grunge music might be. And again, the key thing with concepts and categories is that everyone's concepts and categories and groups of things, they're all different, because not everybody has the exact same experience. So, everybody's concepts are going to be different, and they're going to be based on the individual experience that every individual has.

Now, what is categorization? Well, categorization is the process by which we place things into groups, called categories. So, for example, how is it that we place objects into groups of cars, into groups of music genres? All these things are what the process of categorization is about.

And finally, what is a category? Well, a category can be thought of as a class or group of similar things, objects, or entities. So, for example, fruit, vegetables, cars, fish, mammals – all these things are categories, and they're based all on how we can actually group objects or things together into groups.

So, what role, then, do categories and concepts form in our mental life? Well, I'm going to take this quote right from Smith and Medin, 1981, from your textbook, and what is says here is that "Without concepts, mental life would be chaotic. If we perceived each entity as unique, we'd be overwhelmed by the sheer diversity of what we experience, and unable to remember more than a minute fraction of what we encounter. And if each individual entity needed a distinct name, our language would be staggeringly complex, and communication virtually impossible." Fortunately, though, we do not perceive, remember, and talk about each object and event as a unique entity, but rather, as an instance of a class or concept that we already know something about. This quote highlights some of the main functions of categorization. First off, understanding individual cases you have not seen before, and allows you to make inferences about them. So, for example, consider a Duck-billed Platypus. You might not have ever seen a duck-billed platypus before, but if somebody told you they were a mammal, then, what you would know is that this duck-billed platypus likely has lungs, and it likely breathes air. Consider, also, the Green Sandpiper. Well, you might not have ever heard about a Green Sandpiper before, but if I told you it was a bird, then you'd be able to infer from that that this object, this thing, could fly, and again, that is based on your knowledge of birds, the category of birds.

So, as you can see from these examples, here, having categories and concepts of objects helps you reduce complexity in the environment. You don't have to store each and every bit of information with each specific example of bird. Rather, you can have concepts and categories that help you organize and store that information, which, in turn, requires less learning and memorization. And, finally, having the knowledge of a specific category of an object helps guide you to the appropriate action. So, for example, if you see a four-legged creature with a tail coming toward you, your classification of it as either a dog or a wolf has implications for whether you'll want to call it, run away, pet it, or shout out for help.

So, in summary, concepts help us to establish order in our knowledge base. They allow us to categorize, giving up mental buckets in which to sort the things we encounter, letting us treat new, never before encountered things in the same way we treat familiar things that we perceive to be in the same set, and categorization allows us to make predictions and act accordingly.

7b | Theoretical Descriptions of the Nature of Concepts

We're now going to discuss different theoretical descriptions of the nature of concepts. So, here we're going to concentrate on different ways in which it is thought that concepts and categories might be represented in the mind. We're going to cover five different views: the classical view, the prototype view, the exemplar view, the schemata view, and the knowledge-based view.

First, let's consider the classical view of categories. Now, here, category membership is thought to be determined by a set of defining properties, and when we say defining properties, what we mean are those properties that are deemed necessary and sufficient. These two attributes, that of necessity, and sufficiency, are a little bit different to dissociate, but it's important to understand them, as they are a key property to the classical view. So, in order to get a good grasp of them, let's look at table 7.1. Here, along the top, what we see are different categories, so bachelor, triangle, uncle, and prime minister, and then we have the concepts and features associated with them. So, let's take a look at the category "triangle." The features listed along "triangle" are three-sided and planar. So, how might these relate to the concepts of necessity and sufficiency? Well, to say that a feature is individually necessary is to say that each example must have that feature if it is to be regarded as a member of that category. So, three-sided is a necessary feature of the concept "triangle." Things that do not have tree sides are automatically disqualified from being triangles. Now, what about sufficiency? So, to say that a set of features – now, the key thing here is "a set," meaning more than one feature – is collectively sufficient, is to say that anything with each feature in the set is automatically an instance of the concept. For example, the set of features "three-sided and planar" are sufficient to specify "triangle." Anything that has both of these features is a triangle. Now, since this is such a key aspect of the principle of categorization, I would suggest that you take a look at the other categories in table 7.1 and think about how the concepts of necessity and sufficiency map on to those features.

There are a number of assumptions put forth by proponents of the classical view of categorization. First off, concepts are not thought to be representations of specific examples, but a list of characteristics. So, for example, you won't have a specific example of a dog or a cat represented in your mind as a member of a category. Rather, what you'll have is you'll just have a list of characteristics, and what you do is, you just simply look at a new instance and match it to those lists of characteristics. Secondly, membership in a category is clear-cut – it's all or none, black or white. There are no grey areas at all; either an object is a member of a category, or it is not a member of a category. And there are no better or worse examples of a category. So, again, for example, take the instance of the category "dog:" a German Sheppard, a Beagle, a Chihuahua – they are all equally represented within the category of "dog."

As you can probably imagine, when looking at the assumptions for the classical view of categorization, researchers have taken issue with a lot of them. So, for example, there are some categories where there don't appear to be any real defining features. So, to take a quote from Wittgenstein, 1953: "Consider, for example, the precedings we call "games" – I mean board games, card games, ball games, Olympic games, and so on. For, if you look at them, you will see nothing really in common at all – but similarities, relationships, and a whole series of them, at that." The point here is that there are a number of things out there in the environment that belong to categories where it is very difficult to come up with a set of defining features. So, just to think about a couple of others, here, how about "dog" or "cat?" Well, for a dog, what would be a defining feature? Well, one of the first things that might come to mind is that it has four legs. But what about that poor and unfortunate dog that got into an accident and lost one of its legs? Does that three-legged dog, did it lose it's category membership, and can no longer be called a dog? I think not. How about "cat?" one of the first categories that might come to mind is "has fur." Well, if you owned a hairless Sphinx, you would think otherwise. The important point here is that the assumption of defining features doesn't fit with all the categories that come to mind.

The second problem with the classical view of categorization concerns its assumption that category membership is all or none. So, again, recall that the classical view holds that if an object or an instance has the defining features, it will be a member of the category. There are no good or worse members of categories. Well, a number of researchers, including Eleanor Rosch and her colleagues, have found that people judge different members of a category as varying in goodness. For example, most people in North America consider a robin and a sparrow to be good examples of a bird, but find other examples, such as chickens, penguins, and ostriches, to be not as good. Evidence for this more graded membership was also found in a number of simple reaction-time tasks. So, for example, participants in a sentence-verifications task were faster to respond to a sentence such as "A robin is a bird," than to a sentence such as "A chicken is a bird." And, in semantic priming studies, highly typical instances often led to better priming than less typical instances. And, like we've seen in other sections of this course, we can use reaction time as an index to how the cognitive machinery is working. Here, faster reaction times likely mean that this information, or this member of a category, is a better member of a category than that which is judged slower.

So, in response to the obvious limitations to the classical view of categorization, Rosch and colleagues came up with what is termed the prototype view. Now, this is very similar to what we've talked about in the perception section a number of modules ago. So what a prototype is, is its an idealized representation of a class of objects. It includes features that are characteristic that are typically, rather than necessary or sufficient, and it's thought to be formed by averaging the category members we have encountered in the past. So, If you think about it this way, what it really means is that you've experienced, throughout your lifetime, a number of examples of a specific category. So again, let's just go back to our friend the dog. So, you may have had experiences with Labradors, with Chihuahuas, with Bulldogs, with all these things, but what we have in our mind is we have a prototype which is more of a fuzzy representation of the most characteristic features of all these animals. And the key thing is that this takes into account, too, each of our own individual and unique experiences. Everybody might have a very different prototype in their mind. This also gets around the problem with the classical view to do with all or none membership. Here, members within a category can differ in terms of protoypicality. For example, let's go back to the dog again, you can have highly prototypical dogs, like, for example, the Lab, and less prototypical dos, like, for example, the Chihuahua. And again, everyone's own experience would determine the prototypicality of the instances within memory.

The prototyping of concepts and categories often refers to the family resemblance structure of concepts, and it uses this structure as a means of explaining typicality and prototypicality. Family resemblance can be thought of as a structure in which each member has a number of features, sharing different features with different members. Few, if any, features are shared by every single member of the category, however, the more features a member possesses, the more typical it is. A good example of the family resemblance principle and how to think about it can be found in figure 7.1. This is a figure of who are known as the Smith brothers. Note that they have several shared features – light hair, bushy moustache, large ears, and eyeglasses - and not every Smith brother has every feature. But, the brother in the middle, having them all, would be likely to be judged by the Smiths' friends as the most typical Smith of the bunch. Note that he shares big ears, the eyeglasses, the light hair, with the brother in ten o'clock position, and the moustache and big ears with the seven o'clock brother. Different pairs of brothers share different features, but not all of them have a single, necessary, defining feature. The prototype view of concepts explains typicality effects by reference to this family resemblance principle. The idea is that the more characteristic features an instance of a concept has, the stronger the family resemblance between that instance and other instances, and therefore, the more typical an instance is.

Returning now to our dog example, a Labrador is probably thought of as a more typical dog than a Chihuahua, because the Labrador possesses more characteristic dog features. Even with well-defined concepts, like bachelor, like we talked about in table 7.1, some examples seem more bachelor-like than others. So again, if you'd just look at the defining features which we all probably agree with, the defining features for a bachelor, are adult, unmarried, and human. Is the Pope a bachelor? Or how about an eighteen year old high school student? The point here is that both people may meet the technical definition of a bachelor – they're adult, unmarried, and human – but neither is such a good example, as someone such as, say, George Clooney. So, the prototype view seems to do a pretty good job at explaining why certain members of a category are seen as more typical than others. It also explains why people have a hard time providing strict definitions of their concepts, that is, because stict definitions do not exist, at least as far as the prototype view is concerned. And, finally, the prototype view can explain why some classifications are especially easy to make, and others are a little more unclear – the clarity being determined by the number of shared features between categories. The more shared features between categories, the harder the classification, the less shared features between categories, and the more shared features within categories, the easier the classification.

Now, we've kind of painted a pretty rosy picture of the prototype view, but that's not to say that there aren't some problems with it. So, a couple problems I'm just going to highlight, here, are, one, variable categories. The prototype view is pretty unconstrained, so, if you take again the example of games, where do you draw the line? What determines category membership and not? Again, you could have paintball, poker, basketball – again, the list goes on. A second issue with the prototype view is that the typicality of a certain instance of a category can depend on context, again, so typicality is not fixed. If you think about a robin, a robin might be a typical bird you might find in a park in the city, but a less typical bird on a farm, where maybe a chicken might be the more typical example.

The previous two views of categorization that we've talked about held that concepts were some sort of mental abstraction, or summary of information. For example, the classical view held that we had stored lists of defining features that were necessary and sufficient. The prototype view held that we had some sort of abstract representation that was a summary of previous experiences. Were going to talk about the exemplar based view now, which makes just the opposite assumption of that. It asserts that concepts include actual representations of some real instances that we've experienced in the past. Here, when you categorize an object, or you categorize a new instance that you see, you do this by comparing this new instance to some representation of previously stored instances, or exemplars. Now, similar to the prototype view, the exemplar view assumes that there are no defining features that are associated with specific categories. It also explains why some objects or items are more difficult to categorize than others. Recall when we were talking about the prototype view, categorization was difficult when you had an object that shared features with multiple categories. Again, the key thing with the prototype view is that objects to be categorized in the same category needed to share more features with other objects within the category than between categories. A similar thing is thought to be going on with the exemplar view. However, here, categorization becomes difficult when an instance that you're trying to categorize is similar to exemplars from multiple categories. Take, for example, the tomato – now that's a difficult one to categorize, and the reason it's difficult to categorize is because it's similar to both fruit exemplars, such as oranges and apples, and to vegetable examples, such as beets or squash. And, like the prototype view, the exemplar view can explain the typicality effect. So, recall when we talked about the prototype view before, the typicality effect was determined in part by the number of shared features that specific example that you're trying to categorize shares with the prototype. The more features that example shares with the prototype – the more feature overlap there is – the more typical that example is, and the faster you'll be able to respond to it. Well, a similar thing goes on with the exemplar view. Here, typical instances are thought to be more likely to be stored than less typical ones, or, to be more similar to stored examples. So, this explains why people are faster to process information about typical examples.

Now that you have a pretty good idea about how the exemplar view explains categorization, it would be a good idea to go through the experiment by Allan and Brooks, 1991, that we present in the textbook, and that's referred to in figure 7.2. You'll want to read it carefully because there's a lot of very key details in that experiment that you'll need to understand in order to fully grasp their findings. Now, the key thing is, with that experiment, is they show that physical similarity to previously stored exemplars influences categorization despite participants having a simple and sufficient rule to follow. Put another way, here, previously stored exemplars were the most powerful cue used by these participants to categorize new instances. And participants, even though they had access to some simple rule to use, they pretty much ignored that rule. They just stuck to using the previously stored examples in memory. The other interesting thing with this view is that, oftentimes, people will make use of these previously stored exemplars, without even being consciously aware of it.

And, of course, like all the views we've talked about so far, there are problems with the exemplar view. The big problem, just like the prototype view, is that people do argue that it is a little bit unconstrained, so it's hard to define where category boundaries are, and, why some objects, or some things, will be stored as exemplars, and others will not. Plus, it requires that we store lots of exemplars. So, the classical view of categorization is pretty economical, in that we only store certain features, stored with general classes of objects . The prototype view argues, again, that we have these prototypes, which are generalized representations of objects . The exemplar view, however, argues that we store exemplars: specific instances of objects that we've experienced in our lives. This requires that we store lots of exemplars, and, as we know from different sections of this course, we don't have an infinite storage capacity, so how is it that we can store limitless amounts of experiences that we all have?

The final two views of categorization that we're going to talk about, the schemata view and the knowledge-based view, are a little bit more abstract, and perhaps a little bit more difficult to grasp, because of that. We're only going to discuss them briefly, however. The schemata view of concepts is that concepts are a form of schemata – they're frameworks of knowledge that have roles, slots, variables, and so on. This is very much related to what we talked about before, in the earlier modules on memory, so, for example, how you might have stored information about more general classes of things, more general classes of objects. So, for example, you might have a schema for a car accident, and within that schema you might have things like, well, there's broken glass, well, there's police, well, there's all these things together. Also, schemata may involve both abstractions across distances, like we talked about in the prototype view, and it may involve information about actual, specific examples that we've experienced, like we talked about in the exemplar view. As you've probably gathered, from our brief coverage of the topic, here, and from reading through the section in the textbook, the main problem with the schemata view is that it is really ill-defined, and since it's so ill-defined, it's very difficult to empirically test it.

The final view of categorization that we're going to talk about in this module is knowledge-based view. Now, here, the argument is that people don't just look at specific instances or examples and compare them to stored, previous examples, or to prototypes, or to look at defining features. Rather, they use their knowledge of how the concept is organized to justify the classification and explain why certain instances happen to go together in the same category. The key thing here is that a category only becomes coherent or meaningful when you know what the purpose of the category is. So, consider the following items: children, pets, photo albums, family heirlooms, cash. So, on the face of it, these things just seem to be all from disparate categories, however, when a home is about to be engulfed in flames, well, that new situation would create a new category, or a new meaning: things to save. Note that each one of those objects mentioned is probably precious to the owner, and probably irreplaceable. Notice here that the category only becomes coherent and meaningful once we know the purpose of that category.

This view highlights, again, the flexibility of categorization, and the individuality of it, as well, because it depends on each individual's knowledge of how concepts are organized, the purpose of the category, and people's own individual theories about the world in which they're trying to categorize. And, it addresses the limitations of the prototype and exemplar view, that, remember in those views, it was hard to answer the question of how things actually came together in a category – what defined category boundaries or category membership. Well, here, it's the purpose of that category that actually defines what the category membership is.

So, we've just covered five different views of categorization. And you might be wondering, why do we need five different views? Is the prototype view correct, and the exemplar view wrong? Is the deifning features, or classical view, of categorization right, and the others, wrong? Well the answer's not that simple. I think the best way to think about it is that they're all probably used, and they're used depending on the type of objects, or types of things that we're trying to categorize. So, take for instance, shapes. Well, when we're talking about shapes, like a triangle, well, those have defining features, so we'd probably use a simple rule of classification based on that classical defining features model. For other things, like naturally-occurring things in our environment, like animals, like mammals, we may be more likely to use something like the prototype view. The key thing to take out of this is that our minds, our categorization system, our categorization machinery, is highly flexible, and it likely uses a number of these tools at its disposal when trying to classify and categorize objects in the environment.

7c | Forming New Concepts and Classifying New Instances

For the remainder of this module, we're going to look at how it is that people can form new concepts. And this is a pretty remarkable feat when you think about it. It requires that people have some basis for generalization. It also requires that people figure out which attributes or features are important or critical for categorization, and which are not. In this section, we're going to first look at explicit forms of categorization, and concept attainment – that is, things that people do at a conscious level. Then, we're going to look at what happens in the brain when people acquire concepts, and then we're going to finish of this section by looking at implicit concept attainment, that is, learning concepts without participants' conscious awareness of the riles.

One of the earliest and most influential studies in concept attainment was conducted by Bruner, Goodnow, and Austin, in 1956. So, Bruner and colleagues, they studied the ways that people attain concepts using card depicting different geometric figures. Examples of these cards can be found in the following figure. Note that the cards each could vary along three dimensions: it could have one of three shapes, being a circle, a square, or a cross, one of three colours, being a black, white, or striped, and one of three borders, one, two, or three. In this task, participants were simple told that the experimenter had in mind a certain concept, such as black circles, or all cards containing two borders and striped figures. Participants were then shown one card at a time that illustrated the concept – in other words, a positive instance. The participants' task was simply to test the cards one at a time to see of they conformed to the rule. They were to do this to determine as efficiently as possible what the rule was. So, just to re-clarify that, the researcher would simply present them with a single card that would follow the rule. The researcher did not tell them what the rule was. So, the participants' job was to simply select cards, and by getting feedback from the researcher, determine what the rule was.

Importantly, the main thing that Bruner and colleagues were interested in were the strategies that people used to test for the rule. They found that participants used three different types of strategies. The first one was simultaneous scanning. Now, in this strategy, participants would test multiple hypotheses at the same time, so, for example, white circles. Notice here that the colour "white" and the shape "circles" requires that participants simultaneously test for two different dimensions of the task, and in doing so, places heavy demands on working memory. A second strategy that Bruner and colleagues found was that some participants used what was called successive scanning. Here, a participant tested one hypothesis at a time. So, rather than testing multiple hypotheses, like in simultaneous scanning, the participant just picks one hypothesis and selects cards, based on that one hypothesis until they are reasonably confident that they figured out what that one rule was. This strategy is relatively inefficient, as it is quite time-consuming, but it does have low demands on working memory. Whereas the former two strategies, simultaneous scanning and successive scanning, are strategies based on testing hypotheses, the final strategy, conservative focussing, focuses more on the card attributes. Here, a participant chooses cards that vary in only one respect from the positive instance focus card. For example, if the focus card had two black crosses, and one border, the participant might next select one of the following cards: a card with two black circles and one border, a card with one black cross and one border, a card with two black crosses and two borders, or a card with two white crosses and one border. If any of these cards was a member of the category, then the participant would logically eliminate the changed attribute as being relevant to the concept. For example, if the card with two white crosses and one border was also a member of the category, then the participant knew that colour did not define the concept. As you can see, this strategy places very low demands on working memory, as it doesn't really require you to hold onto a hypothesis and test it systematically. However, this strategy, unlike the other two that we've talked about, doesn't guarantee a solution. And, when adopting this strategy, you run the risk of just going in circles, and not really every finding the rule. The key thing to take away from this study is that there are multiple different strategies people can adopt to learn a concept. And the strategy that you adopt typically involves a trade-off between the amount of working memory resources required and the efficiency of that strategy. The more efficient strategies typically involve more working memory resources than less efficient strategies.

As we've seen so far in a number of different sections of this course, functional brain imaging can be a useful tool in helping us uncover some of the mechanisms underlying cognitive processes. One area where this has become clearly evident is in that of concept learning. I'm going to uncover one of my favourite brain imaging studies right now, one that I think really helps underlie how it is that people can actually acquire concepts. This is a little bit of a complicated study, and in order to grasp the data, and to really truly understand what it's telling us, it's important to clearly understand the methodologies, and, most critically, the stimuli used in this experiment. The basic gist of this task is that participants were asked to respond to a series of what were thought to be abstract paintings, and they were supposed to respond to them as being done by either the painter Smith or Jones. You can see on the figure where the prototypes for the Smith and Jones paintings are. Importantly, however, participants never received these two paintings. Rather, they judged a series of exemplars. These exemplars were formed by changing the colour of each square with a 7% probability. By doing so, that generated a series of exemplars which were extremely close to one of the prototypes and not to the other. What would happen then is, through practice, participants would learn to distinguish and differentiate between these two categories of paintings and be able to respond to them appropriately. Through a series of trials, it didn't take participants very long to learn these rules, and to be able to correctly classify them. However, what the most interesting part of these data are, are not in those behavioural data, but in the functional brain images. So, if you look at the brain images, what we have it broken down to here are the right hemisphere and the left hemisphere, and early versus late in learning. So, let's first just focus on early learning, that is, at the beginning parts of this task, before they actually reached ceiling performance. And what you see here, is we basically see activations isolated to the right prefrontal and right parietal cortices, and there's really not much going on on the left side of the brain. This is likely due to the idea that the early classification of these stimuli mainly involves the processing of visual patterns of information, without the application of any sort of formal rule. And, when we talk about application of a rule, typically, we think about some sort of verbal mediation of that rule, which, again, we know is the realm of the left hemisphere. And this is precisely what we see that happens later on in training. So, for example, as learning progresses, what we see is that the regions of the left hemisphere begin to become recruited, specifically, the left parietal lobe, and the left dorsolateral prefrontal cortex. So, this shift from more right-hemisphere processing to left hemisphere processing may be the result of the formulation and application of rules. I think this is a nice example of how functional brain imaging provides us with some unique information about the mechanisms underlying cognitive processes that would have been very difficult to acquire without the technology.

We just covered a couple studies, one behavioural, by Bruner and colleagues, and one functional brain imaging, by Seger and colleagues, looking at how it is that people acquire new concepts, to categorize new objects. Those were both examples of explicit categorization, or explicit concept learning, in that participants were consciously making use of cues to try to categorize the objects. A lot of concept learning, however, is more implicit in nature, in that participants are not explicitly using knowledge about category membership to make different discriminations. Rather, they are implicitly, or unconsciously, using that information. And there are numerous examples in the real world that follow more of this implicit learning. For example, learning a grammatical structure in a language. There's a lot of grammatical rules that we might not be consciously aware of that we follow on a day-to-day basis, and don't have to actually consciously think of them, or consciously conjure them up. In situations like that, when the underlying rules are so complex, sometimes its better just to be presented with a bunch of examples, and what will happen is you will unconsciously, or implicitly, acquire the rule, and be able to apply it without really being consciously aware of what the rule is.

So we've just covered how category learning can occur both explicitly and implicitly. The degree to which explicit or implicit processing occurs depends, to a large extent, on the type of task. For example, if it's a very simple task where the rules to be learned are rather simple, a more explicit strategy is probably going to be employed. However, if the task is much more complex, and the rules much more varied, then, a more implicit strategy will be employed. That is, as in pretty much every other area of cognitive psychology that we've been talking about so far, the way that people will go about processing this information, or categorizing this information, again, is very, very flexible, and it's going to vary depending on the situation at hand.

7c1 | The Seger Experiment

I thought it would be useful to look at a short little video clip that shows how the stimuli were presented in the Seger et al experiment where they looked at how the brain changes as a function of category learning. This clip is a shortened version, as the actual experiment took several minutes, and I just wanted to give you a sense of how the stimuli would look on the screen. So, like we mentioned before, while participants were in the scanner, what they did is they received a bunch of these different stimuli on the screen, and responded to them whether they thought they were a painting of Smith or Jones. And what you'll see in this clip is that the stimuli was on the screen for 2.5 seconds, and then a participant had to respond quickly to that, and then afterwards they received feedback whether it was actually a Smith or a Jones painting, so that they could learn to distinguish between these two different types of images. I made up this little clip so that it has exactly those specific time parameters that were used in the actual experiment. Also, the reason I wanted to show this little clip is just because it kind of highlights again how FMRI experiments need to have appropriate baseline conditions. Now, we talked about that a little bit in the very first module of this course. In this experiment, after participants received twelve different stimuli to classify as either Smith or Jones paintings, they then received twelve different displays of a simple checkerboard, followed by the word "board." When the received the checkerboard, all they did was press the left or right button randomly. Now, the reason it's so important to have that checkerboard condition, or that baseline condition, as we call it, is that that screen will activate a lot of the same sorts of regions in the brain as the critical stimuli will activate. For example, regions that are associated with processing colours or shapes. That way, when the researchers want to determine the critical regions that are responsible for categorization, they can subtract out those regions that are involved in basic visual perception, and thus be able to isolate those regions that are just involved with category learning. So take a quick look at that short little video that I made, and again, it's just to show you again how the stimuli might appear to the actual participant when they're in the FMRI machine. I only included a couple examples, just to give you a flavour for the task.

8a | Introduction to Visual Imagery and Spatial Cognition

Let's begin this unit with a thought experiment. Think about the street or the block where your current home is located. Including your own, how many buildings are located on your side of the street?

This question forces you to use memory, but a special kind of memory. That is, it is very unlikely that you have the fact, "there are six houses on my block," stored in memory. Instead, in order to answer this question, it is likely that you used a different kind of memory process.

Most likely, you drew a mental map in your mind's eye of your street or block and counted out the houses you saw. You may have even mentally walked past the houses while you were counting. Moreover, you might even be able to name the colours of the buildings as you walk by.

The mental map, or visual image, that you may have used to solve this problem, is the focus of this unit. We will examine how we use these images in order to improve memory, as a kind of mnemonic. Mnemonics are simply techniques used to improve memory and a lot of them include the use of visual memories, or imagery.

We will discuss the nature of these imagery representations, and how we can manipulate them in our minds. This sheds some important light on how information is stored in memory. As we will see, researchers have devised some very clever ways in order to determine how we can process images in our minds.

These experiments also tell us a great deal about how visual/spatial information is stored in memory, which has for a long time been a matter of contention between competing theorists. For instance, do we actually store in memory a picture of our living room that we can recall in order to answer our question about the layout of the furniture, or the number of lamps in the room, or do we store a verbal description, from which we extract the information that we need? This question is at the heart of what is known as the analog versus propositional debate.

Finally, we will consider neuropsychological findings involving imagery. As in the earlier units, we can learn a great deal about imagery from this type of investigation.

8b | Visual Imagery and Memory

You may have already used specialized techniques to improve memory-maybe to memorize vocabulary items for a foreign language class. These are called mnemonics. The ones that we will discuss now involve the construction and use of mental pictures, or images.

Imagine, for a moment, that you are expecting four friends for dinner tonight. You know what you want to serve, and you also know that you don't have any of it at home. You don't have a pen with you, or, amazingly enough, a phone with text capabilities. How will you be able to remember everything you need when you get to the store?

One of the best techniques in this kind of situation is the Method of Loci. The critical framework that one needs to use for the Method of Loci to be successful is a series of well-known places that you encounter in a structured order.

For instance, imagine in detail the trip up your driveway, into the house, and ending in the kitchen. In order to use this technique successfully, you would associate one grocery item with each important location along your journey. After you have made your associations, you would recall your list by re-tracing your steps, exactly as you first performed them, and see, in your mind's eye all of the items that you've stored along the way.

The figure in front of you shows a short memory list along with a series of images you might use as a basis to remember them. This technique can also be supplemented by the use of interactive imagery. For instance, instead of merely imaging hot dogs lying on your driveway, imagine them rolling down the driveway and being covered with pebbles. Interactive images are especially powerful memory aids.

A second imagery-based mnemonic that works very well under certain conditions is the pegword method. This method requires that you first learn a list of ordered paired cues, like those seen in the panel in front of you (one-bun; two-shoe, so on and so forth). These cues are all chosen to rhyme, and you will notice that the first word in each pair is a number, whereas the second is a concrete noun. Each of the items that you wish to remember needs to be associated in an image with the paired cues. For instance, to remember that you have a dentist appointment, you might form the following memory bundle: one is a bun, and imagine yourself biting into a bun and hurting a tooth so that you want to see the dentist. To remember that you have bills to pay, you might encode: three is a tree and form an image of bills hanging in the tree just like leaves. As was the case with the Method of Loci, your memory will be even better if you are able to form interactive images, rather than static ones.

Note that with both Method of Loci and the pegword method, there is an initial investment to be made. That is, if you haven't learned a specific route of locations to use in the Method of Loci or invested the time learn the cue word pairings in the pegword method, they will not be useful techniques for improving memory.

Why do these visually based mnemonics work, and what does their success tell us about how things are stored in memory? University of Western Ontario researcher Alan Pavio hypothesized that visual images are beneficial to memory because they allow information to be stored, or coded in memory in two distinct ways. Let's try a short experiment to investigate this. On the next slide, you will see a list of words. Read through this list with the intent of memorizing them. When you are satisfied that you have learned them, grab a sheet of paper and write down all the words you studied, in their proper order.

Not spoken- Justice; honesty; love; respect; malice; freedom; truth; courage; valor; integrity

Now let's do the same thing with the following list of words:

Not spoken-Cake; table; student; tulip; pizza; pencil; book; sneaker; picture; dolphin

Were you able to recall more words from the second list than from the first? Pavio would predict yes, because according to his Dual Code hypothesis you are able to store the words in the second list using both verbal codes, which are their abstract, linguistic meanings, and image-based codes, you can picture what those things look like. In contrast, the words I chose for list one don't afford dual coding as well. You can encode verbal labels for concepts like justice and honesty, but how well can you form an image of what those concepts look like? Pavio states that having a dual code improves memory over a single code. If you remember back to the units on memory, you will remember that the more retrieval cues that we have available to recall information will lead to better memory. Indeed, it is well-established that people typically do a much better job at recalling concrete items as compared to abstract ones.

Not all theorists agree with Pavio, however, and some have stated that memory for concrete items is superior to that for abstract items not because we can form a visual based memory for concrete items, but because we can generate more detailed verbal descriptions for them. As you see, this debate centers around the nature of representation in memory. Is it the case that we can actually store visual images in memory, and manipulate them just as we would as if the item were in front of us? Or are we limited to only abstract, verbal descriptions? This is the heart of the analog versus propositional debate. Pavio's theory is an example of an analog point of view, and the fact that memory is better for concrete items is consistent with that analog view.

Is there any other evidence that is consistent with the hypothesis that we can store useable visual codes in memory?

8c | Manipulating Visual Images

We've all had the experience of seeing in our mind's eye. But does that mean those images are useful memory codes? Shephard and Metzler published a series of experiments that gave credence to the hypothesis that people can form mental images, and can manipulate them in much the same way that we can manipulate actual objects in our environment.

Imagine that I present you with two complex shapes, perhaps put together out of Lego, and I ask you to tell me if they are the same shape or not? Imagine that instead of putting the shapes in front of you so that they are aligned in exactly the same way, I have the one on the right hand side rotated a bit in a clockwise direction. In order to make sure your decision is correct, you might reach out to one of the shapes and turn it so that its orientation is identical to the comparison shape. If we measured the time for you to make the comparison and respond, we would find that your response time would be longer the greater the difference in orientation or rotation between the two shapes. Shepard and Metzler used this logic in an experiment with mental imagery to see if the same premise held true. That is, when making a comparison of two images, would we mentally rotate one of the objects or images in order to aid in a correct response?

The panel in front of you shows some examples of the shapes used by Sheperd and Metzler. These shapes were not physically provided to the observers, they were only shown on a slide. Shephard and Metzler presented the pairs of shapes so that they varied either in picture-plane, or in depth, and in both cases, they manipulated how many degrees of rotation separated the orientation of the two shapes. Critically, as you see in this figure, the observers' response times varied directly as a function of the number of degrees of rotation separating the two shapes! This is the same pattern of data we observe when people manipulate physical shapes that are actually placed before them, and it supports the idea that observers are actually performing mental rotation on these images in their minds' eye.

Stephen Kosslyn and colleagues extended this research by showing parallel results in a series of image scanning experiments. To understand the logic of the experiments, pretend that I have placed a map of Canada in front of you. I ask you to put your finger on the city of Montreal. Imagine I then ask you a question about the city of Winnipeg, or the city of Vancouver, that requires you to look at that area of the map. We know that it will take you longer to sweep your eyes and your finger across the map to answer the question about Vancouver than it will to answer the question about Winnipeg. Would the same hold true for images of maps?

To test this hypothesis, Kosslyn presented his observers with maps like you see in the panel in front of you. Observers were asked to study the map until they had it committed to memory. The map was then taken away, and observers were asked to form a mental image of the map they had just seen. Once they had formed the image, they were then given a starting point, say the tiki hut in the bottom left hand corner of the map. From that point, they were then asked a question about a place on the map that was relatively near to the tiki hut, like the tree, or a place that was relatively far from the tiki hut, like the rock. Consistent with the results of Shepard and Metzler, and with the hypothesis that we scan mental maps much like we scan actual maps, Kosslyn and his colleagues found that it took longer for observers to answer questions about places further away from their starting points than it did to answer questions about places closer to their starting points.

Taken together, these types of results appear to provide strong support for the analog view of imagery- that mental images are useful codes in memory- and challenge the propositional view that we store only abstract linguistic codes in memory. It is difficult to see why there should be differences in response time that vary according to the physical separation of items on an imaginary map if all we store are verbal descriptions of these items. The proponents of the propositional point of view, however, suggest that these differences are actually due to demand characteristics. That is, everyone knows that it should take longer to respond to two things that are further from one another and in order to do the right thing in the experiment, observers tailor their responses accordingly.

We'll return to the analog versus propositional debate a bit later in this unit, but next, we'll discuss the properties of visual images as important codes in memory.

8d | Imagery Debate

Finke, in 1989, outlined important qualities that are inherent in visual images. The first is implicit, or non-intentional encoding. This means that without overtly encoding that information, it is possible to access the image in memory and retrieve it. In order to understand this, form an image of a block letter “F”. It should look like this. Now, close your eyes and form an image of the F you just saw. Starting at the upper left hand corner of the F, I would like you to scan the F in a clockwise manner, and at every corner you encounter, respond yes if that corner is at the extreme top or bottom of the F, and no if it is not at the extreme top or bottom./

Your responses should have been this: yes, yes, no, no, no, no, no, no, yes, yes.

The fact that you were able to do this means that you were able to retrieve from the image information that you probably never consciously thought about before. This is part of an experiment that was done by Lee Brook at McMaster University, and we’ll return to the rest of the experiment in just a moment.

The second property of visual images that sets them apart from mere abstract propositions is perceptual equivalence. That is, imagery, and manipulating those images, should activate similar brain and mental systems as does actual perception of the physical item. The mental rotation and map scanning experiments we talked about earlier are consistent with this. To really make this point, however, we will try one more condition from the experiment reported by Brooks in 1968. For this condition, you will need to reform the image of the block letter F that you used just a few minutes ago. Your task is going to be exactly the same as before. That is, you are going to begin in the upper left hand corner of the letter, and travel clockwise, indicating at each corner whether that corner is at the extreme top or the extreme bottom of the letter. Instead of responding by saying yes or no, however, I have provided a response sheet for you. On the next slide, you will see 10 rows that each contain a Y and an N, one for each corner of the F. In order to respond, I would like you to start at the top row, touch either the Y or the N to indicate your first response, and then respond to the second corner on the second row, and so forth until you have responded to all the corners and your finger ends at the bottom of the screen.

You probably found this task much more difficult than the first. Brooks argued that this is the case because you need to use your spatial processing skills both to examine and move around the image of the letter F, and to find the proper response row and letter. If you remember back to our attention unit, this is a clear case where we are seeing interference from two controlled processes that are trying to use the same processing resources.

Finke’s third principle is spatial equivalence, which states that the spatial relations in images should correspond to spatial relations in the actual physical space. Kosslyn’s map scanning results provide strong support for this principle.

The fourth principle, that of transformational equivalence, was demonstrated when we talked about Shepard and Metzler’s mental rotation experiments. That is, our performance in mental rotation, or image transformation, was very similar to performance in transforming or rotating actual objects.

The final principle advanced by Finke was that of structural equivalence, which means that images should be organized much like physical objects. Results consistent with this principle have been shown in studies like those of Kosslyn and colleagues. They showed that it took people far longer to form more complex images than simpler images, much like the two pictures of the alligator in part (A). Interestingly, the time to form the same image was also shown to vary according to how it was described. Observers shown the object in panel (B) took longer to form an image of it if was described as five connected boxes than did those observers who were told that that object was two overlapping rectangles.

To summarize, Finke's principles are important in outlining the qualities that visual images should have in order to be important codes in memory. These principles are consistent with the qualities held important by the analog view of visual imagery, as well. As we'll see, however, not all theorists believe that visual images should be considered useful representations in memory.

We've already spent quite a bit of time talking about results that are consistent with the analog view. That is, that visual images are actual visually-based codes stored in memory, that closely resemble the original object. Even more importantly, there is evidence that we can manipulate these so-called pictures in the head much like we manipulate actual objects.

Not everyone agrees that images are useful representations in visual memory, however. That doesn't necessarily mean that these theorists dispute the fact that we can form images, but they do not believe that images per se are true memory representations. Instead, these theorists argue that images are merely by-products of abstract verbal or propositional codes. We may form images as a consequence of activating an abstract verbal code, but we do not process them or operate on them as we would operate on a physical object.

What about the results that we've discussed earlier that seem to indicate that we do process images in much the same way as we process visual objects? Proponents of the propositional point of view, led by Zenon Pylyshyn of the University of Western Ontario, argue that many of those results can be explained by the concept of demand characteristics and by the fact that we have a lot of implicit knowledge about the world. That is, as we discussed earlier, people know that it should take longer to move between two points that are further apart, and that it should take longer to rotate an object the further that the object has to be rotated. Pylyshyn says with this knowledge in hand people behave accordingly.

Pylyshyn also raises a second interesting point. That is, you can look at a picture that you've never seen before and determine what it is. Can you do the same thing with an image? That is, do you ever examine an image in your mind without first knowing what it is? Pylyshyn argues no, because images are by-products of verbal descriptions.

This debate was hotly contested in the 1970s and 80s. Recent advances in technology, however, and the advent of neuropsychological case studies have pushed the weight of the evidence in favour of the analog point of view, as we will see in the next section./

As noted earlier, although we all had the experience of seeing in our mind's eye, or seeing an image, that does not necessarily mean that information is stored in memory as a visual image, or that these images are actual memory codes that can be processed and manipulated. This issue is the center of the analog versus propositional debate.

Recent advances in technology and the use of neuropsychological case studies have provided evidence to help clarify this debate. For instance, Martha Farah and colleagues used a method developed by Stephen Kosslyn to provide a clever demonstration that processing images appears to recruit the same brain areas as does processing actual visual space.

Kosslyn asked observers to imagine an animal at its normal size- for example a mouse. Once the observer had this image formed, Kosslyn asked him or her to "mentally walk towards" the mouse. Observers reported that the size of the image grew as they got closer to it, until they reached the point at which it overflowed their visual field. Kosslyn asked them to estimate how far away they were from the animal when its image overflowed the visual field. Observers in these experiments reported that the visual field was completely filled at a distance further from the animal when the animal was larger than when it was smaller. This is the same thing that we would experience if we approached real animals. In other words, an entire elephant would overflow your visual field before an entire mouse would, as you moved towards the two.

The occipital lobe of the brain is primarily associated with vision, and it is well known that if part of one's occipital lobe is removed, the field of vision decreases.

Farah cleverly combined the experimental work of Kosslyn, and our knowledge about the effect of the occipital lobe on determining the size of one's visual field in a case study. A woman by the initials MGS had part of her right occipital lobe removed as treatment for epilepsy. Before surgery, Farah had MGS perform Kosslyn's mental walk task that we just discussed, and she recorded the estimated distance that MGS reported for overflow of the images of various animals.

These same tests were repeated after surgery, and Farah found that MGS's reported distances of overflow were much smaller than before surgery! That is, removal of part of the occipital lobe not only reduces our physical field of view, but our field of view for images, as well! It is hard to account for such a finding by way of a propositional view of visual imagery.

DeVreese in 1991 also made the important discovery that people who have lost the ability to see colour due to brain damage are also unable to create colours through imagery!

Finally, the work of Bisiach and Luzzatti that we discussed in our attention unit also supports the view that we process visual images much like physical objects. Specifically, their patients suffering from unilateral neglect ignored not only the left side of space when processing items in the real world, but also when processing visual images of their home towns.

Generally, then, advances in neuroscience have bolstered the experimental results that suggest that the analog view is closer to the truth with regards to visual imagery.

8e | Summary of Visual Imagery and Spatial Recognition

Visual images are mental representations of our perceptual experiences. As such, they are important codes that we store in long term memory and can process in working, or short-term memory.

Images can also play an important role as mnemonic, or memory enhancing, devices. Techniques such as the Method of Loci, the use of interactive images, and the Pegword Method have all been shown to help promote memory, and it is quite likely that they do so because they provide two distinct ways that to-be-remembered items can be stored in and retrieved from memory, the so-called Dual Code theory.

We've discussed important evidence concerning mental imagery from studies using mental rotation, imagine scanning, and more recent neuropsychological work. Taken together, these results have allowed us to name important principles of mental images, including implicit encoding, perceptual equivalence, spatial equivalence, transformational equivalence, and structural equivalence. Mental images therefore prove to be an important memory representation- we can store information in visual form, and we can also process and retrieve information from those images.

9a | Introduction to Language and Cognition

In this unit, we will explore one of the most complex, and, uniquely human, cognitive abilities. Your ability to comprehend and produce language, whether it be spoken or written, is a phenomenal achievement, one that you no doubt take for granted. Our ability to use language draws upon all of the units that we've covered to date, from basic perception and attention to the storage and retrieval of concepts, meanings, spellings and pronunciations in memory. Moreover, think about how hearing that ad for a Caribbean holiday in the dead of winter leads you to conjure up an image of crystal clear water, white sand, and a gentle breeze. The units that we cover after this one, the higher-order cognitive skills like reasoning and decision making draw heavily on language. In short, it is an integral part of human cognition.

Is language uniquely human, though? Clearly, other animals can communicate, and many do so with quite a lot of complexity. For instance, when it is time to find a new nest, there is a species of ant that send envoys out to scout for a new location. Having done their best to find a new living place, these scouts then return and communicate to the rest of the ants about the new home so that the entire colony can make a decision. Unlike human language, however, this communication is only about the location of the potential nest. The ants cannot describe what they saw along the way, what the weather was like, or anything else. Therefore, although other species seem to have what are sometimes sophisticated methods of communication, and these methods are often quite structured, which is a requirement of a language, they do not seem to have language per se.

Two aspects of human language set it apart. First, it is arbitrary. That is, there is no direct link between a word that represents a concept and that concept. The word brown does not look like brown. Hungry doesn't feel like hungry. These are arbitrary words chosen to represent concepts. That is not the case with other animal communication.

Perhaps most importantly, human language gives us an ability that makes human life incredibly enjoyable. Our language is generative. That is, every single one of us can state, write or sing something that no one has ever said before.

Thus, language is an incredible feat. In this unit we'll spend some time talking about the structure of language- all languages have structures, and as masters of a language, we are masters of its structure, even if we cannot explain all the rules.

We will also then talk about both language comprehension and production. Obviously these are related topics, but we will also see that they can be done quite independently.

Finally, by examining some of the neuropsychological work that has been done on language, we will reinforce our knowledge about its structure, and we will also see that comprehension and production are separate abilities, recruiting distinct brain areas.

9b | The Structure of Language

When we speak about the structure of language, we will identify a number of different systems that work together, and it is probably not surprising that different systems are invoked depending on whether one is discussing auditory or visual language.

Think about the most basic elements of auditory language as you listen to my voice right now. The first stage in understanding what I am saying is to perceive the sounds I am speaking to you. These are called phonemes, and different languages have different phonemes (and different numbers of phonemes). Phonemes are the smallest unit of sound that makes a meaningful difference in a language. For instance, substituting the phoneme "m" for "c" changes "cat" to "mat." Phonology is the study of how phonemes can be combined in a language.

Phonemes are assembled to create morphemes, which are the smallest units of meaning in a language. In the word cats, "cat" is a morpheme, as it means the concept of a furry house pet, but "s" constitutes a morpheme, as well. In this case, it means more than one cat. Morphemes need to be assembled in some manner that makes sense, and this is called the syntax of the utterance. Syntax is the structure of our language. Having proper syntax is not enough to communicate an idea, however, as the utterance must be semantically meaningful. Finally, in order for communication to be complete, there must be some form of give and take between the participants. We call this the pragmatics of the language. We'll talk about each of these in a bit more detail now.

Even if you speak and read only one language, you no doubt know that different languages make use of different phonemes. German, for instance, uses phonemes that are not used in English, and one of the difficulties of mastering a new language is being able to produce new phonemes as a native would. The table in front of you gives examples of some of the phonemes in the English language. As you try to produce some of these phonemes, notice that your mouth takes on different shapes, your tongue meets the back of your teeth or the roof of your mouth in a different manner, and air is forced from your mouth in a different way. These are regular and important differences that characterize these different phonemes.

As we noted briefly earlier, there are explicit rules for how phonemes can be combined to form an utterance- some combinations of phonemes are not legal, for instance beginning a word with two consonants is only possible when they are certain consonants. Interestingly, although you probably never think about these rules, you would notice a violation of the rules almost instantly.

As we noted earlier, morphemes are the units in our language that convey meaning. Many morphemes are words, but not all are. As you study this unit, you already know that "study" is a morpheme. If you remove the "y" and add an "ied" however, you have added a morpheme, because the meaning of the word has changed from something you are about to do, to something you have done. Word endings, prefixes, tense markers and the like are all morphemes.

How do we combine these morphemes into a form that makes sense? Syntax refers to the arrangement of words within sentences, or their structure. English is primarily what we refer to as an SVO or subject-verb-object language. You may have vague memories from studying grammar, or the syntax of your language in grade school, and may even be vaguely familiar with tree diagrams like that shown here. These diagrams allow us to identify the component parts of a sentence. These diagrams also allow us to see how parts of sentences can be meaningfully rearranged. For instance, the original sentence, seen in the Figure, is The poodle will chase the red ball. It is also possible to reverse the order of the two noun phrases in the diagram, and make a small change to the verb phrase, and be left with an utterance that means essentially the same thing. That is, "The red ball will be chased by the poodle." This is known as preposing, and in this case it is possible. It is not always possible, however. For instance, the utterance "Martha stood up her blind date" cannot be modified in the same way. Up her blind date, Martha stood, simply does not work.

This raises an interesting distinction, that is: we have way more implicit understanding of our language than we are able to explicitly state. Everyone of us can reject as illegal the second utterance, yet that doesn't mean we can explain why.

This also raises another issue, and that is the issue of what a linguist means when he or she says an utterance is grammatically or syntactically correct. Although your grade 8 grammar teacher would likely tell you that it is improper to state, "I ain't gonna do my homework anymore," a linguist would find that a completely legal, albeit perhaps shortsighted statement. That is, a linguist speaks of how utterances must be constructed in order to follow the rules of English, not whether the utterance is particularly proper or polite.

Having a syntactically correct utterance, however, does not mean that it will serve its purpose. Language is meant to communicate, and without proper semantic content, an utterance is useless for that purpose.

The semantics, or meaning, in language, explains many interesting things. For instance, the concept of anomaly- why "Coffee ice-cream can take dictation" is meaningless, the concept of self-contradiction- as illustrated in "my dog is not an animal." When I say that I need to go to the bank, am I speaking about a financial institution or the side of the river? Many words in English are semantically ambiguous, and we need context to disambiuguate them. Likewise, English is rife with synonymous statements, so it is clear to all of us that having someone tell you that you are too young to do something means the same as saying that you aren't old enough. Finally, we are able to derive much more from an utterance that what is explicitly stated. For instance, if I were to tell you that Pat was my uncle, you would know that Pat is a male.

The key to understanding the meaning of an utterance, then, begins with understanding each of the words, but also requires that we be able to understand the syntax, or the way that the utterance is constructed, and the truth value of each part of the utterance.

To this point, we've been able to get a grasp on how one can construct an utterance that informs, which is the point of language. This is only part of the story, however, because to communicate with someone else, you also need to follow a fourth set of rules- the social rules of a language, or its pragmatics.

Pragmatics are the practical rules that we use in maintaining conversations- things like using proper etiquette. We understand that conversation must have give and take, and that we should wait for a response before interrupting and continuing with our point of view. Moreover, our understanding of pragmatics ensures that we speak to our elders and employers in a way that is different from how we might speak to a friend over a beer.

With a general understanding of the many layers of structure that are part of human language, we'll turn now to a closer examination of how we comprehend and produce language.

9c | Language Comprehension and Production

Just as you're able to see the form, colours, texture and shape in front of you as a coffee mug, you must be able to transform raw data in order to comprehend language. One of the most awe inspiring (yet rarely considered) skill that human comprehenders have is speech comprehension. We've spent a bit of time earlier talking about the elemental sounds in the language, the phones, and the smallest sounds that carry meaning, the phonemes. This might lead you to believe, then, that comprehending speech means being able to "hear" each of these phonemes. That is, that we perceive each of these sounds one at a time, using the pauses between the sounds to help us identify when one ends and when the next begins.

This is not the case, however, our ability to comprehend language relies on something much more complex. First, speech is continuous. The Figure in front of you shows a speech spectrogram of a person uttering a phrase. A spectrogram is a physical representation of the frequency of sound plotted over time. As you can see from the spectrogram, speech is not distinct, but is continuous. Where in the spectrogram would you say the individual is saying the word "a?" A second problem with the discrete comprehension view is that an individual phoneme can sound very different, depending on the other phonemes that are around it. Think of the phoneme associated with the letter "p" when it begins a word such as pumpkin, as compared to when it begins a word such as phone.

Given these challenges, how is it that we can process speech so readily, and seemingly without effort? One theory is that we process speech in a categorical manner, meaning that we are "hard wired" to efficiently, without awareness or intention, force sounds into discrete categories. Interestingly, it has been shown that distinctions in sound that we can hear as infants can no longer be made by us once we have learned English. From that point on, we perceive sounds in categories that fit with the phonemes of our language. This is true not just of English speakers, but of speakers of other languages, as well. For instance, speakers of the Cantonese dialect of Chinese cannot distinguish between the English phonemes r and L, although they can do so as infants.

Clearly, then, our ability to comprehend spoken language is complex. What about our ability to produce it?

One of the more interesting areas of study in speech production centers on speech errors. Speech errors are often of a specific type. In one case, we might substitute one phoneme for another, as in "sue keeps food in her vesk." Other times, a phoneme might be shifted from the proper location to a second location. "Keep your cotton-pickin' hands off my weet speas." We also sometimes shift a combination of phonemes, or a more complex sound, as in "got a lot of pons and pats to wash." Finally, other speech errors result from the exchange of complete words or morphemes, as in "We'll sit around the song and sing fires." Notice that in each of these cases the errors are not random, but in their own way they obey the laws of the language. That is, they involve transposing entire phonemes, or more complex sounds, or even morphemes and words. Even our mistakes, then, appear sensitive to the rules of the language.

9d | Neuropsychological Views and Evidence

Our introduction to the concepts of language structure- namely it's meaning and syntax- and our ability to both comprehend it and produce it alluded to the fact that these are separable facets of language. That is, it is possible to utter a meaningful utterance in a syntactically incorrect manner, and it is possible to comprehend language without being able to produce it, and vice versa. In fact, our ability to comprehend language develops much earlier than our ability to produce it, as the parent of any toddler can attest to.

We will now turn to a closer look at neuropsychological evidence that underscores the separability of syntax and semantics, of comprehension and production. As in earlier units, much of this work has relied on the case-study methodology- the in depth study of language in an individual who has suffered some form of brain injury.

There is a special term for a collective deficit in language that results from brain damage, and that is aphasia. We will now discuss some of the aphasias, focusing on two- Broca's aphasia and Wernicke's aphasia.

Broca's aphasia, also called expressive aphasia, was named after the French surgeon Paul Broca. He had encountered a patient, who had been nicknamed "Tan" because he had lost his ability to speak any words except for "tan." After the patient's death, Broca performed an autopsy, and discovered a lesion in the left frontal lobe. This became known as Broca's area, as seen in the Figure. Broca's aphasia is characterized by halting, agrammatic speech. These individuals generally can express semantics, as in nouns and verbs, but the function words, or the connectors that hold our syntactically correct utterances together, are missing. Generally, then, we say that an individual with Broca's aphasia has fairly intact semantics, but badly impaired syntax. Moreover, they have fairly intact comprehension, but badly impaired production. An important limit is present in their comprehension, however. They can comprehend sentence such as, "The dog bit the boy." but make errors on sentences such as "The boy was bit by the dog." These are called reversed sentences, and notice that in order to understand them, you need to rely a little more heavily on your knowledge of syntax.

The following clip shows an individual with Broca's aphasia being interviewed by a psychologist. Notice how he seems to be tracking the conversation and his responses, although short and syntactically impaired, are appropriate for the conversation.

We'll contrast his behaviour with the individual we see in the next clip.

In contrast to Broca's aphasia, which affects one's ability to produce language most dramatically, Wernicke's aphasia has been termed receptive aphasia, but these individuals produce relatively fluent speech that is meaningless. That is, for them, semantics are greatly impaired although syntax is relatively intact. Moreover, their ability to produce language is spared (aside from the fact that it has no meaning), but they cannot comprehend it. Even simple commands such as "touch your knee" will generally not be comprehended and executed by an individual suffering from Wernicke's aphasia. Like Broca's aphasia, Wernicke's aphasia was named after the surgeon who discovered damage to the temporal lobe of the left hemisphere of an individual suffering from it.

An interesting way to conceptualize the difference between Broca's aphasia and Wernicke's aphasia is the following. Imagine you are a first time visitor to a country whose language you do not speak. If you were to run into an individual suffering from Broca's aphasia on the street, you would immediately realize that something was wrong with him or her. In contrast, you would not be able to make the same discrimination about an individual suffering from Wernicke's aphasia. His or her word salad would sound ok to you, because all utterances in that language are meaningless. Here is an example of a patient suffering from Wernicke's aphasia speaking in English.

Just as we noted that there were many forms of agnosia in our unit on perception, it is also the case that there are many forms of aphasia. There are several forms of anomia, which are typically difficulties in naming objects, forms of alexia, which are visual language impairments (dyslexia itself is a large class of alexia), agraphia, which is the inability to write, and interestingly, alexia without agraphia. These individuals can write, but cannot read what they have just written!

An important contribution that the study of language impairment has made is that it has clearly demonstrated the separability of semantics and syntax (meaning and structure) and comprehension and production. These areas are served by different parts of the brain, and it is clearly the case that language, in humans, is strongly lateralized. That is, for the most part, language in right handed individuals resides most strongly in the left hemisphere of the brain.

9e | Summary of Language and Cognition

As we have seen, language is a complex and phenomenal skill- one that is uniquely human. We've discussed five levels of structure- including phonology, morphology, syntax, semantics and pragmatics, and successful language relies on all of these.

As we have seen repeatedly throughout this course, context strongly affects language, just as it affects perception and memory.

We have seen that language is conducted by a number of specialized, independent brain regions. This means that not are the different language processes subserved by different areas of the brain, but it is also possible to have some abilities preserved while others are damaged by some form of brain accident.

Finally, the key to what makes human language unique is two-fold:

First, that you get the gist of what I am saying right now is remarkable given that the words I use to convey this message are arbitrary. They bear no physical resemblance to the concepts that they represent. Second, you can tell your roommate the story of language and do so in a unique way. Human language is generative!