Module: Psychological Foundations of Mental Health

Week 2
Cognitive processes and representations

Topic 1
Perception – Part 1 of 2

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Lecture transcript

Slide 3
Let's start by looking at what the challenges are for perception. The crucial point is the incoming sensory information from our eyes, ears, touch receptors must be interpreted. It's not possible to passively absorb all of this information and thereby perceive it.

Why must it be interpreted? First it must be interpreted and the incoming information arriving in our sensors does not contain all the information that we need in order to perceive it accurately. For example, a cup partly behind a jug is still a cup, and we immediately interpret it as such rather than thinking, look there's a part of a cup with no handle behind that jug.

Secondly, although information is often incomplete, there's a huge amount of it, and we don't need all of this to function well or achieve our goals. For example, when we sit down in our clothes on a chair, the touch receptors all over our body where our clothes are and where the chair is in contact with are constantly being activated, and this information is going into our brains. However, it doesn't make sense for us to continuously perceive or list them as sensory information.

Thirdly, from this incomplete and yet overwhelming input, we must extract what's important to us. Some of this information is extremely important, indeed, and this could be for simple goal-directed reasons like wanting a cup of tea and looking for a cup in the earlier example. But also a crucial task is to be consciously perceiving as soon as we can what might be dangerous to us. For example, we must become aware if something is becoming too hot, for example, the chair you're sitting on or whether a smell has entered the environment and it could be toxic or perhaps whether a loud bang nearby is part of ongoing background work or something that's imminently dangerous.

You can get a sense yourself of the fact that our brain is constructing and interpreting our sensory input into this conscious perception. If you think of a time maybe when fear or worry could have caused you to perceive something incorrectly, think about waking up from a nightmare in a dark bedroom. You might perceive a mound of clothes as a scary figure, or a squirrel in a bush might sound like a much larger entity if you're rushing through a park late at night. So our brain must select the input of greatest importance and allow us to consciously perceive this as accurately as possible in spite of the poor quality of information in our environment and the vast amount of unnecessary and irrelevant stimulation.

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Slide 4
All our sensors are important to us, and they all provide unique information that enables us to function well and enjoy our lives. However, I've chosen to focus on vision for this topic. There are a number of really important reasons for this. Firstly, a large amount of the brain is concerned with vision. In fact, it's the only sense to have an entire lobe of the brain dedicated to it, which is known as the occipital lobe or cortex, and I'll talk about this more in a moment.

Secondly, seeing is actually a really difficult task for our brains and studying vision can give us a great insight into the fact that perception is not passive but it involves this construction and interpretation that I was talking about a moment ago. Thirdly, interacting with our environment is crucial to us as human beings. And arguably, vision is the sense that provides us with the best source of information to enable this interaction.

For example, it provides us with excellent information of what is out there. Is there a person smiling at us as we walk into the room? What do they look like? Is that the friend that we've come to meet? But also it tells us where these important things are. Is the person that we're looking at to the right or the left of a waiter carrying a huge tray of drinks that we should avoid?

And vision, also using this what and where information, provides us with evidence to enable us to prepare for action. This could be simply walking towards our friend, waving back at them, or maybe running away if we've smiled at the wrong person.

Slide 5
Before we move on to the neural pathways that are involved in vision, let's have a look at some common misconceptions about how visual perception works. Often, similar misconceptions are held about other sensors too, and so it's useful for you to think about these senses as we discuss vision. Firstly, we often hear people describe vision as taking place as if the visual world is projected into our eyes and brains like in a cinema. This and similar descriptions suggest that casual observers might believe visual perception to be an automatic or effortless process.

Leading on from this misconception, is the suggestion that this would mean our eyes send an exact copy of what's in front of us at any moment directly to our brains. For example, if you're looking at a chair, the idea would be it would arrive in your occipital cortex as an intact mental image of a chair. Thirdly, we experience or feel that we experience a rich and continuous visual environment in which we are fully perceiving everything around us at any moment. But all of these misconceptions are false.

Vision must interpret the visual input and construct a representation. And much of how we think that we're seeing the world is actually an illusion, and this will become clear by examining visual processing within the brain.

Slide 6
Understanding visual perception means understanding the root of visual processing from the eyes to and through the brain. Learning about visual cortex, which as I've mentioned is called the occipital lobe or occipital cortex, will demonstrate to you the complexity of vision and reveal how it's not simply a passive projection of the outside world into the brain.

First, let's look at these figures of the visual field, eyes, and the main tracts for passage of information from the retina to the brain. In the part of the figure labelled visual field, the lighter colours on each side are where information is only going into one eye, the eye on that side of space. The darker shaded areas moving more centrally show where the visual information is actually entering both eyes.

This means that only the middle section of the visual field is perceived binocularly, that means in 3D. The coloured sections you can see in the back of the eyes is representing the retinas, and these are where all the rods and cones are, rods and cones, the light receptor cells that we need in order to see.

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Rods work when we have very little light available in the visual field. They're not sensitive to colour information, and so vision in the dark is black and white. The cones, which are sensitive to colour information, work only in well-lit conditions and enable colour vision. They are found only on the part of the retina labelled fovea in the figure right at the back of the eye in the middle.

If you look at the central arrows, you'll see that directly fixating an item so that it's central to the visual field means that this information is what falls directly onto the fovea. One of the implications of these first two points, that binocular vision is only possible for the middle part of the visual field and that colour vision only occurs for the items that we're directly fixating, is that our mental representation of seeing all the world around us in rich, three-dimensional colour and detail is not, in fact, the case. Our brains fill in this information for us. More about this filling in will come later.

After the retina and fovea, the visual input leaves both eyes by the optic nerve. And you can see on the figure that these two sources of input then meet at the optic chiasm. At this point, the information from each side of the visual field, the left and the right, are brought together as separate streams and are directed to opposite sides of the brain.

Information from the left visual field goes to the right hemisphere, and from the right visual field, it goes to the left hemisphere. Look at the color-coded streams from each side of the visual field in the figure. The separate sources of information then go to a subcortical area of the brain called the thalamus. The thalamus is analogous to a hub for sensory information entering the brain relaying incoming input to relevant parts of the cortex for the more detailed processing. The part of the thalamus specifically concerned with visual information is known as the lateral geniculate nucleus, or the LGN.

The LGN directs most at this visual information via the optic radiations that you can see in the figure to an area of the occipital lobes known as primary visual cortex, or V1, or sometimes striate cortex. These three terms all refer to the same thing.

Slide 7

Two important principles of vision are useful to understand in order to help the organisation and functions of the occipital lobes make sense to you. The first is that vision is organised hierarchically. The brain starts by processing the most simple properties of the visual input, and then more complex properties are added in as neural processing continues. That is, dots and lines are extracted first from the input.

Edges are then added, then the dots, lines, and edges are formed into objects. The movements of the object are then added and so forth. So this makes it clear there's no representation of, for example, a chair or such things arriving in V1 from the visual input in front of you.

Second, vision is modular that means specific parts or modules in visual cortex deal with specific types of visual information. V1 deals with the fundamental elements of our visual input. For example, the lines making up everything falling within our current fixation, if V1 is damaged, we become cortically blind, or if part of it is damaged, we're blind for input from the relevant part of the visual field.

V1 is crucial for the most fundamental extraction of visual input from the incoming information, and without this extraction, no further analysis of the information is possible, Hence, the blindness. Further examples of specific modules are V4, which deals with colour information. And so damage to V4 in both hemispheres leads to loss of colour vision.

But as V1, et cetera is intact, you would have preserved vision for forms of objects and their motion. V5 is a different module within visual cortex, and it deals with motion. So damage here leads to motion blindness, but all other aspects of the visual scene are processed accurately.

If you look at the figure displayed here, you can see the labels of V1, primary visual cortex, and

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onwards. And I use the word onwards as you might be able to tell from what I've said so far that once visual information arrives at V1, it then makes its way forward in the brain through the other occipital regions. And I'll go into some detail of these paths in the next slides.

Slide 8

Looking at the image on the slide, you can see two arrows moving forwards through the brain from the blue shaded area of early visual cortex, or V1. The top green arrow here is moving into parietal cortex, and this stream represented by this arrow is known as the dorsal stream.

The bottom pink arrow is known as the ventral stream. The term dorsal refers to locations nearer the top of the brain, and the term ventral to locations nearer the bottom. The dorsal stream of visual processing is often called the where stream, and the ventral stream is often called the what stream, and I'll now describe why that is.

Slide 9

The ventral stream, as you can see in the figure, runs from V1 to the temporal cortex. The type of information processed in the ventral stream concerns what the visual elements are, starting with the construction of simple forms, then shapes, and finally whole objects. This includes some dedicated processing of category-specific information, for example, faces. Also V4 that I mentioned earlier is part of the ventral stream dealing with colour recognition.

The function of these areas in visual experience has been demonstrated very clearly in neuropsychological studies of patients suffering from visual agnosia. This is a disorder in which following damage to parts of the ventral stream, patients become unable to recognise objects or even when more severe and affecting areas nearer to primary visual cortex, simple shapes. These patients can see and they know that something is being presented to them, and they can recognise simple features like lines or corners, yet they remain entirely unable to visually recognise what something is.

The specificity of the problem to vision is made very clear if the patients are allowed to explore the item with their hand, and they can often identify it immediately. It's not that fundamental vision has been lost and it's not that knowledge of what the objects are have been lost as might occur in some types of dementia. It's the combination of basic visual features with its object-related characteristics.

Slide 10

The dorsal visual stream running from primary visual cortex to parietal cortex is primarily concerned with spatial information. That is where things are in the world around you where they are compared to you and where they are in relation to one another. It's also crucial for 3D vision and V5, the motion area, is also part of this stream. Nearer imaging studies dissociating the two streams, for example, Haxby in 2009, have shown activations in dorsal stream for location judgments and ventral stream for object recognition decisions.

Our ability to spatially represent the outside world is linked with attention, which I'll be talking about in detail in the next topic. And the primary attention area in the brain is, indeed, parietal cortex, i.e. it's part of the dorsal visual pathway. The disorders that follow damage to dorsal stream cause striking spatial representational deficits primarily affecting the side of space opposite the brain injury, and I'll talk about this in the next section.

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