Discovering Psychology: Updated Edition

03 The Behaving Brain

1	01:00:16:17	>> ZIMBARDO: Can new computer techniques tell if a person is an alcoholic, a manic depressive, or a schizophrenic, or if he might become one in the future?
2	01:00:28:02	Can transplanting healthy tissue into the brain help treat disease or actually improve memory?
3	01:00:38:21	"The Behaving Brain," this time on *Discovering Psychology* .
4	01:01:16:00	>> ZIMBARDO: This is a cauliflower, a rather bland two-pound vegetable with limited gourmet potential.
5	01:01:23:08	And this is an adult human brain, weighing about three pounds.
6	01:01:28:16	They may look somewhat alike, but within this small, fragile mass is the most complex structure in the known universe.
7	01:01:38:16	There are about as many cells in the brain as there are stars in our galaxy -- about ten trillion.
8	01:01:49:27	Although they come in more than 200 different types, these cells, called neurons and glia, are all designed to do just three things: receive information from other cells, process it, and then transmit it to the rest of the body.
9	01:02:07:06	All behavior begins with the actions of the neuron.
10	01:02:12:04	First, it gathers incoming information at one end from receptors spread around its branch fibers, or dendrites.
11	01:02:20:14	Next, the information is sent to the neuron's cell body, or soma, where it's combined with other incoming information.
12	01:02:30:09	Then the entire input is passed along within the neuron's extended fiber, or axon, in the form of an electrical discharge, or nerve impulse.
13	01:02:42:18	The impulse ends up here, at the neuron's terminal buttons.
14	01:02:47:11	These buttons contain chemicals which are subsequently released, sending, in effect, a chemical message to adjacent neurons.

15 01:02:57:13 Although packed tightly together, no two neurons actually touch.

16 01:03:02:20 They have to send their messages across the liquid-filled gap between them -- the synaptic gap, or synapse.

17 01:03:11:09 These chemical messages are called neurotransmitters.

18 01:03:16:21 When a neurotransmitter is released into the synapse, it attaches to specific receptor sites on the membrane of dendrites in neighboring neurons, like a key fitting precisely into the tumbler of a lock.

19 01:03:32:13 Some synapses are excitatory: the neurotransmitters cause the neuron on the other side of the synapse to generate a nerve impulse -- an electrical charge.

20 01:03:44:21 While other synapses are inhibitory, reducing or preventing nerve impulses.

21 01:03:56:18 The receptor channels in the dendrites determine what the effect of a neurotransmitter will be, as the sum of all excitatory and inhibitory inputs determines if the next neuron down the line will fire and at what rate.

22 01:04:14:03 This constant flow of nerve impulses and transmitter chemicals throughout our body gives human behavior its incredible complexity.

23 01:04:25:05 It regulates our metabolism, temperature, and respiration.

24 01:04:36:00 It enables us to learn, remember, and decide.

25 01:04:44:27 What's so difficult to comprehend is that somehow within these nerve cells and synapses is the basis for communicating all that we can possibly know and experience.

26 01:04:56:21 How that happens is a profound puzzle for those scientists who study the brain and behavior.

27 01:05:03:06 They're a new breed of researchers called neuroscientists, drawn from about 20 different disciplines, including psychology.

28 01:05:11:26 Neuroscientists are guided by the assumption that everything the brain does is ultimately explainable by biological and chemical events taking place within it, either

throughout the entire brain, or in a particular region.

29 01:05:31:23 For these researchers, understanding behavior means knowing its biological foundation.

30 01:05:39:12 The brain is an integral part of the nervous system, and it works in a holistic way, with all its parts interacting, although some regions are specialized for getting particular jobs done in the most efficient way.

31 01:05:53:26 Let's take a quick tour so we can learn our way around.

32 01:05:58:10 First stop is the brain stem, which connects the brain to the nerves in the spinal cord.

33 01:06:04:16 It's the center for basic life support: breathing, the beating of the heart, waking and sleeping.

34 01:06:13:05 Connected to the brain stem at the back of the skull is the cerebellum, which has the task of coordinating body movements, controlling posture, and maintaining equilibrium.

35 01:06:24:27 Next, deep within the brain, is the limbic system, which contains several structures that make up the old mammalian brain that we have in common with other mammals.

36 01:06:36:10 It maintains the balance of the body's internal workings -- its temperature, blood pressure, and sugar levels, among others.

37 01:06:44:01 It also regulates emotions, and the powerful drives of self-preservation and sexual desire.

38 01:06:51:12 The four most important parts of the limbic system are the amygdala, the hippocampus, the hypothalamus, and the thalamus.

39 01:07:05:05 The amygdala is the pathway into the limbic system for sensory impulses.

40 01:07:11:14 The hippocampus is a basic information processor.

41 01:07:15:20 It matches new information to information that's already stored in the brain.

42 01:07:20:26 It also stores some kinds of memories.

43 01:07:24:18 The hypothalamus acts as a liaison between the body and

		the rest of the brain, releasing at least seven different hormones to the pituitary gland, which in turn releases hormones into the bloodstream, influencing growth and sex.
44	01:07:41:26	The thalamus is a relay station sending signals from the rest of the body to the appropriate regions of the brain.
45	01:07:50:20	Surrounding these evolutionarily older, more primitive structures that make up the limbic system is the cerebrum -- in humans, the largest part of the brain.
46	01:08:00:05	It's here that nerve impulses get translated into images, symbols, words, and ideas.
47	01:08:09:10	The cerebrum is divided into two halves -- the cerebral hemispheres, which are connected by millions of nerve fibers that make up the corpus callosum, a conduit for messages traveling between the right and left sides of the brain.
48	01:08:27:06	The outer layer of the cerebrum is the cortex -- the familiar convoluted surface of the brain.
49	01:08:33:28	The center of conscious thought, perception, and integration of all sensation and responses; top management in the hierarchy of the brain's activities.
50	01:08:44:29	To probe the secrets of all these regions of the brain requires many different methods, some old, some brand new.
51	01:08:52:02	The earliest information came from autopsies of patients with brain damage, stroke, and disease -- patients in whom certain behaviors, like speech, had been impaired.
52	01:09:02:17	Later, with animals, researchers used lesioning, the precise destruction of brain tissue, in order to correlate any loss of behavioral and sensory functions with a loss of tissue in a given region of the brain.
53	01:09:15:08	Or they stimulated a specific region with minute amounts of electrical current or chemicals.
54	01:09:22:01	Today, the newest approach is brain imaging, which can measure the brain's structure or its functioning.
55	01:09:30:15	Imaging provides researchers, psychiatrists, and surgeons with actual pictures of the brain's inner workings.

56 01:09:41:20 But the most widespread technique for understanding brain functions is to record the brain's electrical activity.

57 01:09:50:13 Because neurons are biochemical electrical generators, neuroscientists have found ways to record the nerve signals coming from a single neuron as a response to some event.

58 01:10:02:16 The electrical activity of the entire brain can also be recorded.

59 01:10:07:27 This brain wave pattern is known as an electroencephalogram, or EEG.

60 01:10:13:11 It represents the total activity of the neurons in the cortex.

61 01:10:18:26 E. Roy John, director of the Brain Research Laboratories in New York, is a leading proponent of the new science of neurometrics, the precise electrophysical measurement of neural functioning.

62 01:10:33:09 >> We, and scientists in other laboratories, have looked at the electrical activity of the human brain across the age range from early childhood to old age -- specifically from six to 90 -- and describe the electrical activity quantitatively by analyzing it using computers.

63 01:10:53:29 What we have found is that this electrical activity changes in a very orderly way which can be described by simple equations.

64 01:11:03:17 The basis of neurometrics is that every individual's brain electrical activity is compared to these normative data which we have collected across the lifespan.

65 01:11:17:14 The way this comparison is made is statistical.

66 01:11:21:10 The data are presented in a way which is intended to attract your attention to abnormal features, because there's such an enormous amount of information that's being evaluated by the computer.

67 01:11:36:18 So the information's color- coded.

68 01:11:40:02 If brain electrical activity in a particular anatomical region is normal, that part of the image which the computer presents is an earth color.

69 01:11:52:03 To the extent that there is an excess of some kind of activity

in a particular region, that region becomes colored red.

70 01:12:01:04 The more abnormal the excess, the brighter the color of red, going up to orange.

71 01:12:07:02 If there is something lacking in an anatomical region, if it's deficient in a certain kind of activity, that region becomes colored blue.

72 01:12:17:09 When abnormalities are present, they appear as blotches of color in certain regions.

73 01:12:22:29 We have now patterns that identify the major psychiatric disorders -- depression, dementia, schizophrenia.

74 01:12:32:26 We can recognize alcoholism.

75 01:12:35:15 Neurometric analysis is a functional analysis.

76 01:12:40:15 It reveals abnormal transactions between brain regions.

77 01:12:46:05 Those regions may interact abnormally for several reasons.

78 01:12:51:07 One is because their anatomical structure is abnormal, which we can see.

79 01:12:57:26 Two is because in spite of normal structure, their neurochemical reactions are abnormal, which we can also see.

80 01:13:08:23 Even with normal neurochemical capability and normal anatomical structure, the brain can enter certain states which are abnormal.

81 01:13:25:07 For example, we had a patient come in for an examination who was a staff member here at the university, who was known to the technician who was performing the examination.

82 01:13:42:08 Really wasn't a patient -- the person came in as a member of our normal database.

83 01:13:50:29 An examination was performed, and the results were perfectly normal.

84 01:13:56:18 After completion of the examination, the technician who knew this volunteer asked her a personal question about her boyfriend.

85 01:14:08:00 And in fact, this person had had a very distressing rupture of her relationship with the boyfriend.

86 01:14:17:12 While she reacted to the question, accidentally, the recording continued.

87 01:14:24:14 And that recording was analyzed and showed pathological depression.

88 01:14:30:14 So here we had, in a matter of a couple of minutes, a brain move from a perfectly normal picture to a pathologically depressed picture, and in fact, a couple of minutes later, back to a perfectly normal picture.

89 01:14:43:19 That was not abnormal neurochemical capability or structure -- that was a state.

90 01:14:51:21 And what we can see is the change of state as people think of different things, as they have different moods.

91 01:15:02:00 Almost everybody knows somebody who's been in countless years of psychotherapy with very little apparent benefit.

92 01:15:09:20 Many of those treatment- resistant patients in fact have pathophysiological causes for their behavioral distress which can now be recognized.

93 01:15:21:00 Psychology for a long time has dealt with the organism like a black box.

94 01:15:26:07 Something comes into it and something comes out from it.

95 01:15:29:12 And you infer what's in between by the relationship between the input and the output.

96 01:15:36:05 With those inferences, bright people can learn a lot about what's in between, but it will never compare with being able to open the box and look inside.

97 01:15:43:19 And that's where we're at now.

98 01:15:46:11 >> ZIMBARDO: While some neuroscientists explore the electrical activity of the brain, others are studying its chemical activity.

99 01:15:54:24 One of the most promising avenues of research today is the effect of drugs on specific functions of the brain.

100 01:16:02:15 The brain itself is a biochemical drug factory that manufactures opiate-like molecules.

101 01:16:10:07 These molecules are called opioid peptides, part of the complex system of neurotransmitters that send signals from cell to cell and ultimately to other organs of the body.

102 01:16:24:15 Although there are many different types of opioid peptides, they're known collectively as endorphins.

103 01:16:33:01 These endorphins also come with corresponding opioid receptors throughout the body.

104 01:16:39:22 There is a finely tuned division of labor among them.

105 01:16:43:00 As each endorphin follows a specific path within the nervous system, the action of each one is mediated through different types of receptors.

106 01:16:52:00 And what all of them do for us is nothing short of remarkable.

107 01:16:56:22 Endorphins, like narcotics, can create the mood of euphoria that runners experience, and reduce pain, depending on which peptides attach themselves to which receptors.

108 01:17:09:09 In fact, they play a major role in most experiences that involve pleasure or pain.

109 01:17:18:04 Research has implicated them in a host of our emotional reactions, from laughing and crying to physical arousal such as fighting.

110 01:17:26:20 And endorphins are but one of a staggering number of chemical influences on the brain.

111 01:17:34:01 At the University of California at Berkeley, psychologist-neuroscientist Joseph Martinez is investigating how brain chemicals also affect learning and memory.

112 01:17:44:15 >> We find certain chemicals in the brain that we call neurotransmitters.

113 01:17:49:13 And we think that some neurotransmitters are important for learning in animals and humans.

114 01:17:56:09 And by knowing what these chemicals are, we are able to mimic how the brain talks to itself.

115 01:18:02:09 And we can coax the brain into either forgetting an experience, or we can make the brain actually remember better by stimulating some of these chemical systems.

116 01:18:15:11 In our experiments we use very simple learning situations.

117 01:18:20:03 We have a maze which has two arms, and we put the food into one of the arms and the mouse runs down and obtains the food.

118 01:18:29:00 The mouse learns very quickly where the food is, and he always runs to that particular arm.

119 01:18:35:05 Even though we've trained them in this maze task, their memories are not yet fixed.

120 01:18:40:22 They're not yet permanent.

121 01:18:41:29 They're not yet into long-term memory, because the brain is still processing this information.

122 01:18:48:03 And since it takes a period of time to become permanent, we can interfere with this process by injecting the animals with drugs.

123 01:18:57:29 In this particular experiment, one group of animals we had injected with the drug called scopolamine, which blocks the transmission of information in the brain.

124 01:19:07:29 And the other group of animals had simply received a saline injection.

125 01:19:12:02 The animals are trained in a drug-free state.

126 01:19:14:23 They don't receive drugs while they're learning the maze.

127 01:19:17:13 When they're finished with their training, we then inject them with the drug, and we find that the drug produces an experimental amnesia.

128 01:19:25:17 The animals don't remember the maze.

129 01:19:27:19 They wander around the maze trying to find the food.

130 01:19:30:14 This is a synapse which contains the neurotransmitter acetylcholine.

131 01:19:39:12 In the experiment, we used a drug called scopolamine.

132 01:19:42:07 Now, scopolamine blocks the receptor site for the neurotransmitter acetylcholine.

133 01:19:47:23 So in a sense we've inactivated this synapse.

134 01:19:51:01 When we do that it leads to experimental amnesia.

135 01:19:54:12 We can also do the opposite.

136 01:19:55:27 We can stimulate this synapse.

137 01:19:59:09 A drug which does this is called physostigmine.

138 01:20:02:29 It blocks the enzyme which breaks down the neurotransmitter acetylcholine so there's more of it around in the synapse to have an effect.

139 01:20:12:17 When you do this, you actually can produce the opposite result, or enhancement of memory.

140 01:20:18:24 The reason acetylcholine is interesting in this context is because acetylcholine is the neurotransmitter that's tremendously reduced in Alzheimer's patients.

141 01:20:29:29 So there's great hope that by understanding this particular chemical system better that we'll be able to develop drugs that can help people with Alzheimer's disease.

142 01:20:40:11 >> ZIMBARDO: While brain imaging, experimental drugs, and EEG recordings help improve our understanding of the brain, studying brain abnormalities like amnesia can teach us something about how normal memory works.

143 01:20:54:22 Mieke Verfaellie is a psychologist at the Memory Disorders Research Center in Boston who studies the effects of amnesia.

144 01:21:03:15 >> It's important to dispel a common misconception about amnesia...

145 01:21:07:29 >> Who are you, anyway?

146 01:21:09:29 >> ...and that's the notion that you often see in movies, that when somebody becomes amnesic, they lose their knowledge about themselves, about their past, and that in fact they lose their identity.

147 01:21:20:20 >> I really don't know.

148 01:21:22:27 >> She's got amnesia.

149 01:21:24:03 >> Amnesia?

150 01:21:25:09 I hope that ain't contagious.

151 01:21:28:13 >> Now in reality, it's almost the complete opposite, because what we see is that the main problem is really one in forming and laying down new memories.

152 01:21:35:28 So it's primarily a problem in new learning, and it's not the case that patients don't remember their remote past, or who they were, or where they grew up.

153 01:21:43:23 That's a kind of information that's typically well preserved.

154 01:21:46:17 >> ZIMBARDO: Dr. Verfaellie's research involves working with medial temporal lobe amnesics who've suffered severe damage to the hippocampal region of their brain -- an area critical for laying down new memories.

155 01:22:00:10 >> Trophy.

156 01:22:03:01 Institute.

157 01:22:05:17 >> ZIMBARDO: One of her subjects is Richard, whose amnesia was caused by a viral infection, encephalitis.

158 01:22:11:10 >> One of the tasks that we did with Richard was really to examine his anterograde memory, his ability to learn new information.

159 01:22:20:15 And so typically what we do is we'll give a patient a list of words or a set of pictures, and we'll ask him to remember them the best they can.

160 01:22:29:03 >> You can recall the words in any order that you like.

161 01:22:32:11 >> Okay.

162 01:22:33:26 Doctor.

163 01:22:48:11 Was it cat, or feline?

164 01:22:50:20 I'm not sure.

165 01:22:52:03 >> Okay.

166 01:23:02:21 >> ZIMBARDO: Memory is not static -- it is constantly

developing and evolving.

167 01:23:07:06 New memory takes time to become a permanent record in the brain.

168 01:23:10:29 Some amnesiacs have problems retrieving information that wasn't fully laid down prior to the onset of their illness.

169 01:23:18:18 >> Let me show you another picture.

170 01:23:22:02 Do you know who that is?

171 01:23:23:07 >> O.J. Simpson.

172 01:23:24:10 >> So for instance we asked...

173 01:23:25:11 we showed Richard a picture of O.J. Simpson...

174 01:23:28:01 >> Former NFL football player.

175 01:23:29:23 Retired, I believe.

176 01:23:31:14 >> ...because that's probably something that goes back more than ten years, and so that memory is preserved.

177 01:23:37:10 But strikingly, he didn't know anything more recent about O.J.

178 01:23:40:09 Simpson.

179 01:23:41:17 He couldn't tell us that he had been accused of murder and anything more recent that had happened to him.

180 01:23:47:15 >> I don't recall reading or...

181 01:23:48:28 >> So it really nicely illustrates, he has some information about this individual but it goes back more than ten years and the more recent memories are lost.

182 01:23:57:18 >> ZIMBARDO: The hippocampus is not the storehouse of memory, but the machinery that helps to build new memories.

183 01:24:04:09 Ironically, by looking at dysfunctions in conscious memory, psychologists can better understand some of the complexities of the brain and the way memory works normally.

184 01:24:15:25 Some might argue that as new research uncovers the

biochemical mechanisms that underlie the complexities of human behavior, we'll lose the wonder and mystery of existence.

185 01:24:26:26 But the truth is, when it comes to the brain, the more we begin to know about it, the more we marvel.

186 01:24:36:24 It takes only three pounds of matter to make a human mind, and yet it's designed to do more than any supercomputer hundreds of times its size.

187 01:24:47:26 It's still difficult to comprehend that some combination of chemical molecules flowing between nerve cells in the brain could be the foundation for all our abilities and personality -- our thoughts and feelings, our memories and dreams.

188 01:25:05:14 So now we've seen a few of the ways in which the brain controls behavior.

189 01:25:10:01 In our next program, however, we're going to explore something just as remarkable -- how the brain is changed dynamically by the world around it.

190 01:25:17:14 How it responds to new experiences, new behaviors, and new challenges from the environment by continually modifying itself.

191 01:25:25:24 "The Responsive Brain," next time on *Discovering Psychology* .

192 01:25:29:09 I'm Philip Zimbardo.

193 01:25:33:27 [Captioned by The Caption Center WGBH Educational Foundation] >> *Funding for this program is*

194 01:26:10:19 *provided by Annenberg/CPB to advance excellent teaching* .

195 01:26:20:15 *For information about this and other Annenberg/CPB programs, call 1-800-LEARNER and visit us at www.learner.org* .