

Discovering Psychology: Updated Edition

25 Cognitive Neuroscience

- 1 01:00:16:15 >> *What can psychology tell us about where the processes of the mind are located within the structure of the human brain ?*
- 2 01:00:25:16 *From visual perception and imagination to how we evaluate social groups .*
- 3 01:00:33:12 "Cognitive Neuroscience" this time on Discovering Psychology.
- 4 01:01:14:11 >> ZIMBARDO: In 1848, one man's misfortune began psychology's long journey into the mystery of the human brain.
- 5 01:01:24:13 Phineas Gage, a railroad worker, suffered a catastrophic injury while preparing to blast bedrock.
- 6 01:01:33:20 The iron rod he was using to pack the gunpowder blasted through his skull and tore away the front part of his brain.
- 7 01:01:44:01 Remarkably, Gage never lost consciousness and was even able to joke with the doctor when he arrived.
- 8 01:01:50:18 After a few months, he seemed to recover his health fully, but he was no longer Gage.
- 9 01:01:57:12 Hostile, impulsive, unable to control his emotions or his obscene language, Gage lived 13 more years with this new, disturbed personality.
- 10 01:02:09:00 With this celebrated case, psychologists began to connect brain injury with changes in behavior.
- 11 01:02:16:04 They could begin to map where the processes of the mind were located within the human brain.
- 12 01:02:23:23 But the study of the brain through injury is a slow process, so psychologists have developed a number of tools to measure the brain functions of normal people.
- 13 01:02:35:17 Electroencephalogram recordings, or E.E.G, record brain waves with scalp electrodes.

- 14 01:02:44:09 Event-related potentials, or E.R.P, can record brain waves during specific cognitive events.
- 15 01:02:52:28 Computer-assisted tomography, or CAT scan, can show the brain's structure.
- 16 01:02:59:28 Positron emission tomography, or PET scan, was first to image the brain in action.
- 17 01:03:07:19 But a new tool introduced in the 1990s goes one step further.
- 18 01:03:13:01 Functional magnetic resonance imaging, or fMRI, can show the brain at work in high resolution.
- 19 01:03:21:13 For the first time, psychologists can see the mind's functioning deep inside the physiology of the active brain in normal people.
- 20 01:03:32:02 When our brain is active, it uses up the oxygen supply in that area.
- 21 01:03:37:15 This momentary depletion is followed by an oversupply of oxygen rushed to the site.
- 22 01:03:43:25 This alters the magnetic qualities of the blood -- a change recorded by the scanner.
- 23 01:03:51:07 After further computer processing, a detailed picture of that local brain activity emerges.
- 24 01:03:59:05 With new brain-imaging technology, psychological scientists can explore far more about our abilities than ever before, from better-known systems like perception to less-understood systems like motivation and emotion.
- 25 01:04:15:04 Perhaps our most awe-inspiring ability is how we see the world.
- 26 01:04:20:26 Vision is so complex, about 40% of our brain is devoted to it.
- 27 01:04:26:18 Decades of human and animal studies have revealed what is happening in the early stages of vision.
- 28 01:04:33:27 Light energy converted to neural signals travels from the retina to the thalamus.
- 29 01:04:39:17 Then these signals move to the back of each hemisphere of

- the brain to an area called the primary visual cortex.
- 30 01:04:48:11 It is this area that researchers are beginning to explore with fMRI.
- 31 01:04:54:18 David Heeger has studied some of the specialized functions of this visual center.
- 32 01:05:00:17 >> Of the neocortex, pretty much the back third is involved in some way or another with visual processing.
- 33 01:05:08:09 The primary visual cortex, which is also called V-1, is the first receiving area in visual cortex that receives that information coming from the eyes through the thalamus.
- 34 01:05:19:03 And that's right along here, and rolls over a little bit onto the back side right there.
- 35 01:05:23:08 And from there the neural signals fan out to a whole bunch of other visual areas of the brain.
- 36 01:05:31:04 >> ZIMBARDO: In fact, there may be as many as 40 distinct visual areas in the cortex of the brain.
- 37 01:05:38:21 And some of these visual areas record what we see almost photographically -- a process called retinotopic mapping.
- 38 01:05:50:09 Animal studies show how this works.
- 39 01:05:53:29 In a monkey brain, visual neurons were chemically treated to turn dark.
- 40 01:05:59:26 After seeing this wheel-like pattern, the monkey's brain recorded the image seen here in a section of its visual cortex.
- 41 01:06:09:26 This representation of the physical world is the starting point for further visual processing.
- 42 01:06:16:22 >> So, you know, as I'm looking out here in front of me, at some object, I need to know a lot of things about that object.
- 43 01:06:26:06 I need to know how far away it is.
- 44 01:06:28:22 If it's hurtling toward me, is it small enough that I can reach out and catch it or do I have to duck and get out of the way?
- 45 01:06:33:01 I might want to know something about what color it is, whether it has a texture on it or not.

- 46 01:06:41:15 >> ZIMBARDO: With fMRI, Heeger can observe visual processes at work at the back of the brain.
- 47 01:06:47:24 >> Here we're going to look at an example of how different areas of visual cortex are specialized for different kinds of visual functions.
- 48 01:06:58:23 On the top, you're seeing a flickering checkerboard here that's alternating with a blank gray screen and a pattern of randomly positioned white dots that are first moving, then stationary.
- 49 01:07:10:00 The bottom two panels are showing visual cortex responding.
- 50 01:07:15:07 On the bottom right, in response to the flickering checkerboard you see activity in V-1, primary visual cortex.
- 51 01:07:21:16 On the bottom left, you're seeing activity in the same place, but you're also seeing activity here in the right hemisphere and over here in the left hemisphere -- visual area MT -- that's very specialized for visual motion processing.
- 52 01:07:36:00 >> ZIMBARDO: The visual areas funnel information to two higher processing regions.
- 53 01:07:41:06 The parietal cortex helps us determine where things are in space so we can grab, duck and navigate.
- 54 01:07:50:11 And the temporal lobe helps us to determine what kinds of objects we are looking at.
- 55 01:07:57:13 Nancy Kanwisher of MIT is studying a portion of the temporal lobe where we recognize a high-priority object: the human face.
- 56 01:08:09:17 >> What we usually see is a little patch of brain in the back, in the right hemisphere -- mine is right about in there some place -- on the bottom surface of the brain that produces a much stronger signal when the subjects look at faces than when they look at anything else.
- 57 01:08:27:06 All you need to do is lie there, hold real still and look attentively...
- 58 01:08:31:02 >> ZIMBARDO: This brain activity occurs across a wide range of faces.

- 59 01:08:34:20 Front views, side views, line drawings, cartoon faces, even cat faces all produced a very strong response.
- 60 01:08:45:10 But was it really whole faces that were creating this effect or just parts of faces?
- 61 01:08:49:26 >> One of the things we've been concerned with is to argue that it really is faces per se that this area responds to rather than, say, two little dots, or curvy lines, or other kind of simpler descriptions of features that may be present in faces, but may not themselves be faces.
- 62 01:09:06:21 So if you look at this image, most people can't tell what that is.
- 63 01:09:12:05 On the other hand, if you look at this image, sometimes it takes a second, but most people eventually get it.
- 64 01:09:19:17 This is actually the same image.
- 65 01:09:21:00 So it's not just the curves or dots or angles in the image, because they're the same.
- 66 01:09:25:23 It's the same image.
- 67 01:09:27:19 It's whether you perceive a face in the image or not.
- 68 01:09:32:09 >> ZIMBARDO: For humans and other social primates, decoding faces is essential.
- 69 01:09:40:08 A brief glance can tell you who someone is -- their sex, their mood -- and enables us to judge if they are friend or foe.
- 70 01:09:49:29 Repeated processing of faces over time may actually feed back to change the structure of our brain.
- 71 01:09:58:13 >> It is known that the cortex is very astic, and organizes itself around the experiences it has.
- 72 01:10:05:19 So maybe simply because we look at faces all the time in our daily lives, that is sufficient to produce a special-purpose patch of cortex that does face recognition.
- 73 01:10:14:29 But of course, the other perfectly plausible story is that recognizing faces was so critical to the survival of our primate ancestors that natural selection helped shape cortical machinery dedicated to face recognition.

- 74 01:10:32:17 >> ZIMBARDO: There is another kind of visual processing the brain engages in, and it's called the mind's eye -- the mental imagery that occurs while we think about scenes and objects.
- 75 01:10:43:12 Researchers have now discovered that many of the brain areas used for vision are also the same as those used while we imagine.
- 76 01:10:52:28 Stephen Kosslyn of Harvard University has been investigating the relationship between these two complementary visual systems.
- 77 01:11:01:24 >> Wouldn't it be a pity to let 40% of your brain just be involved in perception?
- 78 01:11:07:28 Why not usurp that, use it in thinking as well?
- 79 01:11:11:20 And that's what mental imagery is all about.
- 80 01:11:14:21 >> ZIMBARDO: Mental imagery allows us to manipulate what we have stored in visual memory so we can use that information to anticipate and solve problems.
- 81 01:11:25:13 >> And this sort of looks like an oxygen mask, but it's actually...
- 82 01:11:30:05 >> ZIMBARDO: With another brain imaging technology, PET scan, Kosslyn's team has studied how visual perception and mental imagery overlap.
- 83 01:11:38:18 On a computer screen, subjects imagined a letter inside a grid.
- 84 01:11:43:14 An x was displayed.
- 85 01:11:45:17 The subjects had to indicate if the x touched the imagined letter.
- 86 01:11:51:08 Finally, they identified objects displayed at oblique angles.
- 87 01:11:57:19 Of all the brain areas active in mental imagery and in vision, two-thirds were activated in common.
- 88 01:12:06:05 We quite literally see with our mind's eye.
- 89 01:12:10:13 We even move our eyes in the same way while we imagine a scene as when we visually scan the scene in the external

world.

- 90 01:12:17:12 For example, think of your living room.
- 91 01:12:19:24 As you do, you'll scan the walls looking for details.
- 92 01:12:25:00 Count the windows, even zoom in on objects in about the same amount of time as you would if you were actually viewing it.
- 93 01:12:36:01 >> When you generate an image, you're conjuring it up.
- 94 01:12:39:08 Often you actually build up an image by putting parts on it.
- 95 01:12:43:03 So you've got forming images.
- 96 01:12:45:01 You've got image inspection which can involve scanning around or zooming in interpreting patterns and images.
- 97 01:12:52:20 You've got holding on to images over time and image transformations which include rotating, expanding, bending various kinds of other things.
- 98 01:13:00:09 Each of those abilities is carried out by a host of separate processes.
- 99 01:13:05:19 We can piggyback on this enormously complicated system that helps us navigate in the world to also anticipate what we would do or to think about possibilities that don't exist currently.
- 100 01:13:19:15 >> ZIMBARDO: Using fMRI, researchers have revealed how the brain is changed by what it experiences; how it is dynamic, never static; how brain structure is changed by brain functions.
- 101 01:13:31:24 It is, in a sense, a plastic brain reshaped by what it learns, remembers and practices.
- 102 01:13:37:23 A powerful example of this responsive brain is learning how to read.
- 103 01:13:42:28 Mastering the complex collection of symbols that represent language is one of childhood's greatest challenges.
- 104 01:13:48:27 It is a learned skill that or time reorganizes our plastic brain.
- 105 01:13:55:13 To understand how the brain adapts to reading, John Gabrieli of Stanford University presents subjects with a

difficult task -- reading text presented backwards.

- 106 01:14:09:09 >> The subject will go into the scanner and perform with words presented mirror-reversed.
- 107 01:14:14:14 And they will perform very slowly and make many mistakes.
- 108 01:14:19:04 After they come out of the scanner we have them practice the task many times in the laboratory until they get much better at doing the task.
- 109 01:14:27:27 >> ZIMBARDO: After thousands of trials, the effort of deciphering the text becomes less conscious, more automatic.
- 110 01:14:35:05 When the subject is expert, it's back to the scanner again.
- 111 01:14:40:21 >> So we have before-and-after snapshots of their brain when they're not good at doing the mirror-reverse text reading versus when they're very good at doing that.
- 112 01:14:51:02 During the initial phase of poor performance, we see lots of activity in the right parietal cortex, a part of the brain that's very involved in visual spatial thinking, and that we interpret as people doing mental flipping of letters.
- 113 01:15:05:12 After people become very good, we see activity in that part of the brain decline -- in fact, disappear -- and now lots of areas in the verbal left hemisphere become active.
- 114 01:15:15:10 It's as if the left hemisphere, the language hemisphere, has gained skill now in dealing with this unusual presentation of letters and your normal language systems can come into play and take full advantage of everything you know about words and letters.
- 115 01:15:29:17 The shift must reflect that when we initially do a task that we're poor at we just don't have the information we need to do well at it.
- 116 01:15:37:11 Through trial and error and struggle and great effort, our minds acquire new information that lets us approach the task differently.
- 117 01:15:45:10 But it must take some time for the brain to get that information in such a way that it can use it -- until enough knowledge is gained through experience to allow other parts of the brain to take over and do a really terrific job.

- 118 01:15:58:25 >> "She climbed to the tippity- top of the tree.
- 119 01:16:02:05 Gazing out on the world she sobbed, 'Where could Mom be?'" >> ZIMBARDO: This kind of practice combined with brain plasticity is the foundation of a child's ability to read.
- 120 01:16:12:23 But for some, reading is a skill that can take years to master.
- 121 01:16:17:07 For children with dyslexia, the challenge is more than a vision problem -- it lies in the spoken part of language.
- 122 01:16:25:19 >> That can be exemplified by the following little game you can play with yourself, okay?
- 123 01:16:32:21 How do you say the word "plate" without the first sound -- the first phoneme, "p"?
- 124 01:16:40:20 And the answer to that is, "late."
- 125 01:16:44:21 Now, individuals who are dyslexic -- who are completely intelligent; have had very successful lives, even as adults many times cannot play these simple games.
- 126 01:16:55:13 >> ZIMBARDO: Phonemes are the smallest units of sound within words.
- 127 01:16:59:10 For example: All together form the word "speech."
- 128 01:17:09:29 >> Speech.
- 129 01:17:12:02 >> ZIMBARDO: These sounds, essential for decoding spoken language, are also the building blocks of reading and writing.
- 130 01:17:21:09 In normal conversation phonemes can be as short as eight milliseconds.
- 131 01:17:26:02 Phonemic awareness requires processing by a high-speed language area of the brain usually located in the left hemisphere.
- 132 01:17:34:23 But for many children with dyslexia this area fails to activate.
- 133 01:17:39:21 It's a problem that interferes with their ability to read.
- 134 01:17:45:28 To solve this problem, Paula Tallal of Rutgers University has developed computer games that capitalize on how the brain changes as skills are mastered.

- 135 01:17:56:06 (*computer saying phonemes*) The computer slows and amplifies the phonemes enough for a child to hear and process them.
- 136 01:18:06:10 (*computer dings*) >> ZIMBARDO: Through thousands of reward-driven trials the games teach the skill of decoding phonemes.
- 137 01:18:16:12 For kids, it's just plain fun.
- 138 01:18:19:11 (*computer dings*) >> Each individual playing these games are getting a completely one-on-one, unique experience mouse-click by mouse-click, minute by minute, which would be very, very difficult to duplicate even with the best teacher or therapist.
- 139 01:18:40:03 (*computer saying phonemes*) (*computer making squeaks*) The computer is able to make these very small and subtle and organized changes to exactly map onto the individual's neural- processing abilities at the moment and change as the individual improves.
- 140 01:18:59:24 >> ZIMBARDO: Repetitive practice with feedback moves the phoneme- decoding skill where it belongs- - into the high-speed language area of the brain.
- 141 01:19:10:14 >> "The duck-billed lizard had a mouth..."
- 142 01:19:14:17 >> ZIMBARDO: The result is a dramatic improvement in reading ability for these children with dyslexia after only a few weeks of training.
- 143 01:19:24:05 >> We're very encouraged by these results, and I think they're a testament to how important it is to understand the neural basis of oral language before we move into the written-language training.
- 144 01:19:40:11 >> ZIMBARDO: From vision and brain plasticity researchers have moved into exciting new areas with fMRI-based investigations.
- 145 01:19:49:05 One is the study of social influences on the brain.
- 146 01:19:52:15 Social psychologists and neuroscientists have joined forces to explore aspects of behavior once thought impossible to locate.
- 147 01:20:01:07 Mahzarin Banaji of Yale University has studied where

prejudice lies hidden in the brain.

- 148 01:20:08:00 >> The human mind is incredibly adept at learning very quickly who sits where, what fits with what.
- 149 01:20:19:09 The question that's of interest to us is once you've learned that association, once you've learned that fact, how are you going to use it in judging a person about whom you may not know very much at all?
- 150 01:20:30:17 >> ZIMBARDO: Our minds are full of knowledge about the status of social groups -- information we have learned and stored unconsciously from the culture around us.
- 151 01:20:42:06 These biased attitudes can be an automatic part of our behavior even when we consciously claim to be tolerant.
- 152 01:20:51:05 How do they affect our ability to serve as jurors?
- 153 01:20:56:21 Or to react correctly in high- stress, high-speed situations?
- 154 01:21:02:18 Are they the difference between life and death?
- 155 01:21:07:08 >> Hi, Amanda.
- 156 01:21:08:19 Today we're going to ask you some...
- 157 01:21:10:20 >> ZIMBARDO: To uncover these hidden attitudes, Banaji has adapted the Implicit Attitudes Test, or IAT, to measure reaction time when we pair positive and negative values to unfamiliar black and white faces.
- 158 01:21:25:04 >> The IAT measures the strength of association between two concepts.
- 159 01:21:30:25 You can imagine how quickly can one pair words like "love," "joy," "peace" -- things that mean good things with the category "African American"; with the category "European American."
- 160 01:21:42:23 The speed with which the two can be connected is an indirect measure of one's level of prejudice towards the group.
- 161 01:21:51:14 >> ZIMBARDO: Banaji and her colleague Anthony Greenwald of the University of Washington have captured thousands of IAT responses from respondents on the Web.

- 162 01:22:02:04 These data have yielded some expected and also unexpected results.
- 163 01:22:07:06 >> White Americans show what we might call an "in-group preference" -- that is, they show a swiftness to associate white with good and black with bad.
- 164 01:22:17:17 African Americans show an interesting pattern.
- 165 01:22:21:01 On average, they show no bias.
- 166 01:22:23:09 About half the African Americans who take this test are showing a pro-black preference -- that is, they're faster to associate black with good than white with good.
- 167 01:22:34:24 But the other half are showing quite the opposite.
- 168 01:22:37:23 They're showing a fast association between white and good, even though they're black.
- 169 01:22:42:28 And this raises the question of the importance of culture.
- 170 01:22:48:15 >> ZIMBARDO: If a positive value for white can overpower our conscious attitudes it should be stored and visible deep within the brain in its emotional center, the amygdala.
- 171 01:23:01:24 To see if her IAT results correlated with amygdala activity Banaji turned to neuroscientist Liz Phelps.
- 172 01:23:10:05 >> When you learn something in the environment fearful or negative the amygdala will become involved.
- 173 01:23:16:28 So we would expect if the amygdala is important in emotional learning and memory, in general that it would also be important in learning about the evaluation of social groups and the emotional properties that we assign to social groups.
- 174 01:23:32:08 >> ZIMBARDO: First, white participants were tested for an external indicator of amygdala response.
- 175 01:23:40:18 When you hear a loud noise you startle and involuntarily blink your eyes.
- 176 01:23:45:18 (*electronic noise*) The strength of this eye-blink reflex can be measured as a baseline.
- 177 01:23:52:14 (*electronic noise*) If an emotionally charged image like a

face is added, the intensity of your response typically increases.

- 178 01:24:00:22 (*electronic noise*) Most white participants blinked more strongly when presented with unfamiliar black faces...
- 179 01:24:07:03 (*electronic noise*) ...an unconscious indication of fear or dislike of them.
- 180 01:24:12:21 (*electronic noise*) Later, in the scanner, their amygdala activity was measured directly.
- 181 01:24:19:27 >> And what was interesting is that we found a correlation.
- 182 01:24:24:09 Those subjects who showed greater amygdala activation tended to show greater startle response to the black faces.
- 183 01:24:33:21 >> These sorts of correlations indicate the extent to which culture produces its influence at every single level.
- 184 01:24:44:10 The big question, of course, remains as to what it is these measures predict in the real world.
- 185 01:24:50:26 Does it matter if a police officer has a large IAT score?
- 186 01:24:55:07 Is such a police officer more likely to shoot at somebody who is black than somebody who is white?
- 187 01:25:03:09 These are not experiments that have been done, but this is indeed where the field is going.
- 188 01:25:08:22 It is for the next few decades to discover.
- 189 01:25:14:12 >> ZIMBARDO: In our next program, we'll move from this micro view of brain cells to a macro view that has given rise to another new branch of psychology -- cultural psychology, the study of how culture shapes our thinking, feeling and actions.
- 190 01:25:28:07 For *Discovering Psychology*, I'm Philip Zimbardo.
- 191 01:25:34:16 [Captioned by The Caption Center WGBH Educational Foundation]
- 192 01:26:10:00 >> *Funding for this program is provided by Annenberg/CPB to advance excellent teaching .*
- 193 01:26:21:01 >> *For information about this and other Annenberg/CPB programs, call 1-800-LEARNER and visit us at*

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