

## ***Discovering Psychology: Updated Edition***

### **04 The Responsive Brain**

- 1 01:28:37:20 >> ZIMBARDO: What makes a premature infant who is massaged regularly develop faster than one who is rarely touched?
- 2 01:28:43:12 >> She's up to 1,470 grams today.
- 3 01:28:45:20 >> Oh, good.
- 4 01:28:47:13 >> ZIMBARDO: How can this tropical fish actually change its size and color when it wins or loses territory?
- 5 01:28:55:19 And what makes this dominant baboon healthier than its lower- ranking cousins?
- 6 01:29:00:23 "The Responsive Brain" this time on *Discovering Psychology* .
- 7 01:29:38:05 >> ZIMBARDO: The brain is the organ of life, the inner universe of intelligence, passion, pain, and creativity, and by understanding how it functions, we can better understand the basic mechanisms that underlie human and animal behavior.
- 8 01:29:54:13 But the relationship between brain and behavior is reciprocal.
- 9 01:29:59:10 The brain controls behavior, but behavior also feeds back information to influence the brain.
- 10 01:30:07:20 In this sense, we can talk about the responsive brain as well as the behaving brain.
- 11 01:30:14:11 Because it's designed to be modified by the behaviors it has caused and by environmental stimulation, the brain is constantly open to change.
- 12 01:30:23:00 It can alter its own functioning and even its structure as it learns more, as it becomes more knowledgeable and sophisticated about the world around it.
- 13 01:30:33:09 This capacity for internal modification makes the brain one of the most dynamic systems on the planet.

- 14 01:30:42:08 To understand how this two-way process of brain and behavior really works, let's use touch as an example.
- 15 01:30:50:15 Touch is the silent language by which people communicate everything from friendship and love to their need to control others.
- 16 01:30:58:19 This personal contact is governed by unspoken cultural rules and regulations.
- 17 01:31:03:19 >> Great.
- 18 01:31:05:03 >> ZIMBARDO: In our culture, men and women respond to being touched in different ways.
- 19 01:31:10:19 For instance, women are more likely to touch, embrace, and kiss friends and family, while men typically limit touch to a handshake.
- 20 01:31:22:19 According to one study, when women were gently touched by a nurse before an operation, they reacted positively with lower blood pressure and reduced anxiety.
- 21 01:31:33:24 The men, on the other hand, got upset by the same kind of touch.
- 22 01:31:38:29 Their blood pressure went up and their anxiety increased.
- 23 01:31:44:08 Researchers have also found that, regardless of gender, those who are quite comfortable with touching others are more cheerful, less conforming, and less suspicious of other people's motives, while those uncomfortable with touching others tend to have lower self-esteem and are generally more socially withdrawn.
- 24 01:32:08:05 The consequences of being touch deprived are extremely significant, not only for our sense of security and emotional well-being, but also for our physical health.
- 25 01:32:18:17 And this is where the brain comes in, for in between the act of touching or being touched and its positive consequences is the brain, which apparently creates a need for touch.
- 26 01:32:29:13 And the most critical need begins at the beginning -- at birth.
- 27 01:32:33:23 The need for a mother's touch is such that both humans and animals thrive when they get it and suffer badly when they don't.

- 28 01:32:41:16 ( *babies crying* ) ( *machines beeping* ) When premature infants are placed in intensive care units which provide every possible life-support system, they still lack one thing -- human touch.
- 29 01:32:56:07 What difference would it make if some of the infants were given daily touch sessions while they remained inside their incubators?
- 30 01:33:05:14 The question was asked by psychologist Tiffany Field of Miami University.
- 31 01:33:11:15 20 premature infants were randomly selected to receive periodic massages, while 20 others got the usual hospital treatment without massages.
- 32 01:33:23:28 In all other respects, the care they received was identical.
- 33 01:33:29:27 >> The premature babies who were massaged for 45 minutes a day for ten days before they were discharged gained weight -- 47% more weight than the babies who did not get massaged.
- 34 01:33:42:26 They were more active.
- 35 01:33:44:19 They were more alert.
- 36 01:33:47:18 These babies, when you see them at eight months, are still showing a weight advantage, and at that time they're showing better cognitive development and better motor development.
- 37 01:33:59:22 >> ZIMBARDO: Not only do the babies fare better, but so does society.
- 38 01:34:05:00 Sending premature infants home early could save millions of dollars in hospital costs each year.
- 39 01:34:12:05 >> 1,470 grams today.
- 40 01:34:13:27 >> Oh, good, she'll be going home soon.
- 41 01:34:15:25 >> She's really gaining a lot of weight.
- 42 01:34:17:28 >> I think the temperature and humidity feel about right.
- 43 01:34:21:01 >> ZIMBARDO: At the same time, Saul Schanberg of Duke University, Field's collaborator, led another research team.

- 44 01:34:28:01 Working with infant rats, Schanberg showed how a mother's touch comes to have real biological value to her offspring.
- 45 01:34:37:16 >> A mother's touch, we know now, is absolutely necessary to maintain normal growth and development of the baby rats.
- 46 01:34:52:26 And what we found was that when rat babies were removed from the mother for even a short period of time, this enzyme -- very important for growth and development called ornithine decarboxylase or ODC, as we call it -- went way down.
- 47 01:35:14:14 So all of a sudden we were faced with a situation, trying to understand how it was that a short-term separation from the mother could have such dramatic effects throughout the body on the actual process of growth.
- 48 01:35:34:24 We have found that the deprivation effects that we see to be reversed by only two ways: one, returning it to the mother, who then licks the pups and goes through the process, or by a technician using a little paintbrush and stroking the pups with a certain frequency and strength that is the pattern touch that we have discovered.
- 49 01:36:09:06 >> ZIMBARDO: Researcher Cindy Kuhn demonstrates how the infant rats are treated.
- 50 01:36:15:12 >> Okay, what we have here is normal active maternal behavior.
- 51 01:36:19:03 She's retrieving the pups, as you see.
- 52 01:36:21:07 We've disturbed her nest, so she's going to gather them back into a ball, lick and stimulate each one in turn -- and rather actively -- and rotate among them sporadically for a short period of time.
- 53 01:36:32:22 Eventually, in five or ten minutes, she'll settle back over them and simply crouch over them so that they can suckle.
- 54 01:36:43:15 What we have here are pups who have been away from the mom for about two hours.
- 55 01:36:48:26 They've had a temporary deprivation of maternal touch.
- 56 01:36:53:18 When I stimulate them with this brush with this very robust pattern, it simulates, we think, how she behaves when she licks them and stimulates them and retrieves them.

- 57 01:37:05:15 The longer, really, they're separated from the mom, we have found, the less responsive they are, which is, again, another sign probably of the deprivation.
- 58 01:37:14:17 But we don't do it at all gently because she doesn't do it at all gently.
- 59 01:37:19:03 And this... it takes stimulation this active to return their enzymes to normal.
- 60 01:37:25:20 >> It's an interesting thought, but one can say here that the need for a mother's touch is really brain based.
- 61 01:37:34:05 It isn't just nice to have it.
- 62 01:37:36:28 It's a requirement for the normal development and growth of the baby.
- 63 01:37:44:15 >> ZIMBARDO: With all this research in mind, you might wonder if lack of affection can actually stunt the growth of human children.
- 64 01:37:52:14 Unfortunately, the answer is yes.
- 65 01:37:55:12 John Bowlby and Renee Spitz conducted a study of institutionalized youngsters who were emotionally deprived.
- 66 01:38:02:10 Although the children were well fed and received good medical care, their rate of growth was significantly below the normal range for their age groups.
- 67 01:38:11:29 Because physical growth is clearly affected by psychological experience, this phenomenon is known as psychosocial dwarfism.
- 68 01:38:21:22 The mechanism by which this emotional deprivation stunted the children's growth seems to be the failure of the brain's hypothalamus, which normally stimulates the pituitary gland to secrete growth hormones.
- 69 01:38:36:12 So the lack of touching may have had the same effect as it did with the baby rats, reducing the production of biochemical substances essential for growth.
- 70 01:38:47:22 ( *children laughing* ) But whenever children are placed with a loving family, they begin to return to normal size.
- 71 01:38:57:16 In one study, these children, who had been emotionally

- deprived, caught up with their peers by growing an average of nearly eight inches in a year.
- 72 01:39:08:03 The normal growth for that period is only two and a half inches.
- 73 01:39:12:12 So it's clear that the functioning of the brain can be altered by behavior and by the social environment.
- 74 01:39:18:15 But what about its very structure?
- 75 01:39:20:21 One of the first attempts to demonstrate permanent alterations in the structure of the brain came in a series of studies at the University of California at Berkeley.
- 76 01:39:29:26 A research team led by Mark Rosenzweig studied the effects of raising rats in an enriched, stimulating environment, as compared to ordinary or impoverished environments.
- 77 01:39:40:18 Not only were the enriched- environment rats superior learners in adulthood, their brains were physically changed by their experience.
- 78 01:39:49:26 The brains of the stimulated rats grew larger with a thicker cortex, especially the occipital cortex, the region responsible for vision.
- 79 01:39:59:27 Also, there was a greater number of certain neurotransmitters and there were more and larger spines on the dendrites -- the branched fibers of neurons which receive signals from other neurons.
- 80 01:40:12:27 These sorts of physical changes in the brain can have a lifelong effect.
- 81 01:40:19:01 Studies have shown, for instance, that touching newborn rats not only stimulates growth, as we've seen, but also helps them to cope better with stress throughout their lives.
- 82 01:40:31:14 And this, in turn, serves to reduce the normal effects of aging, such as learning difficulties and diseases of senility.
- 83 01:40:43:07 Michael Meaney is a developmental psychologist at McGill University.
- 84 01:40:48:10 He's investigating how early experiences can change an animal's brain and behavior -- in particular, how the animal is affected by stress and the release of hormones called

glucocorticoids.

- 85 01:41:02:14 >> When you expose any mammalian species -- animal, human -- to a stressful situation, there is an enormous increase in the secretion of glucocorticoids.
- 86 01:41:13:10 These hormones increase the heart rate.
- 87 01:41:16:00 They decrease digestion and in general allow the organism to better be able to cope with the challenge presented by the stressor.
- 88 01:41:23:17 The problem with extensive exposure to these glucocorticoids is that they can actually literally kill brain cells, specifically the glucocorticoid-sensitive neurons within the hippocampus.
- 89 01:41:34:27 The hippocampus is a structure that is absolutely critical for learning and memory.
- 90 01:41:40:19 And the problem that you face is that with the degeneration of hippocampal neurons in the aged animal is that you begin to see the brain less capable of processing information and you see profound deficits in learning and memory.
- 91 01:41:55:10 What we're trying to do in these experiments is to examine the ability of the animal to learn and remember events, particularly spatial events.
- 92 01:42:06:06 Now, rats are proficient, but reluctant swimmers.
- 93 01:42:09:13 And if you put them in a pool of water, they'll use the first opportunity they can to get out of the water.
- 94 01:42:14:18 When you compare the handled and nonhandled animals, the older handled animals look very much like the younger animals.
- 95 01:42:21:16 Within a very few number of trials, the animals are quickly able to learn where the platform is located and it takes them very little time to swim to the platform and get out of the water.
- 96 01:42:30:28 When you look at the older nonhandled animals, these are the animals that show you major hippocampal cell loss.
- 97 01:42:36:19 These animals take an awful long time to learn where the platform is located and show you very, very poor memory for

where the platform is located.

- 98 01:42:51:04 What you're looking at presented here on the monitor is the digitized version of the position of the rat and the position of the platform.
- 99 01:42:58:04 What this equipment does is to give us two pieces of information: first of all, the amount of time that it takes for the animal to actually find the platform and the distance swam by the animal prior to finding the platform.
- 100 01:43:09:03 Both of these are our measures of exactly how well the...
- 101 01:43:12:02 actually the animal knows the location of the platform with respect to the cues in the room.
- 102 01:43:18:06 The question that we're trying to pose is that... could an individual's ability to cope with stress be a factor that predicts whether or not we see intellectual impairment in individuals and how early it shows up?
- 103 01:43:31:08 It's very possible that the individual differences in intellectual functioning among elderly people are really related to their ability to cope with stress, and so that in the individuals who are showing you intellectual impairments -- 55, 60 years of age -- that these people might be like the nonhandled rats, less capable of dealing with a stressor, more likely to show you increased glucocorticoid exposure, more likely to show you loss of hippocampal cells, more likely then to show you the cognitive impairments that derive from these hippocampal damage.
- 104 01:44:06:09 >> ZIMBARDO: But perhaps the clearest and most startling example of the brain altering its structure and functioning in response to social situations can be seen when the brain works together with evolution to ensure the survival of the fittest.
- 105 01:44:32:02 With his theory of evolution, Charles Darwin made us aware of what "survival of the fittest" really means -- that those animals who are best able to adapt to the challenges of their environment pass on their genes to their offspring.
- 106 01:44:46:22 ( *elk trumpeting* ) Russell Fernald of Stanford University is a new breed of psychological scientist, a neuroethologist who applies the methodologies of brain science to the study of animal behavior in their natural habitats.

- 107 01:45:04:06 His work dramatically illustrates the interaction of brain, behavior, and environment.
- 108 01:45:10:27 >> When you think about behavior, the thing that occurs to you primarily is that it's controlled by the brain.
- 109 01:45:17:05 And yet, what an animal does -- in fact, what we do -- can also change brain structures.
- 110 01:45:23:10 And I have chosen to work on a model system, the African cichlid fish, because we have now discovered that in their social system, the way in which they interact regulates many aspects of their brain structure and even their body structures.
- 111 01:45:38:14 >> ZIMBARDO: Fernald has found that cichlid fish undergo physical change based on changes in their social environment.
- 112 01:45:46:11 This phenomenon offers rare insight into the mechanics involved in transforming social information into physiological change.
- 113 01:45:55:17 >> So when a nonterritorial male recognizes there's a chance for him to become dominant, this male will turn on his eye bar first.
- 114 01:46:05:09 Slowly the brighter colors will appear on his body.
- 115 01:46:08:07 He'll begin attacking and chasing another male and occupy a territory through vigorous defense.
- 116 01:46:14:26 Inside, what's happening is a very interesting set of signals go from the recognition of this social opportunity to a region of the brain called the hypothalamus.
- 117 01:46:24:10 This hypothalamic region is conserved across all vertebrates.
- 118 01:46:28:10 We have one as the fish do.
- 119 01:46:30:19 In the brain region, the hypothalamus, cells containing a particular signaling peptide in this fish get eight times larger.
- 120 01:46:38:03 They send out eight times as much signal.
- 121 01:46:40:24 That signal goes to the pituitary gland, which then signals the gonads, and the gonads enlarge also by several orders

of magnitude in these dominant males.

- 122 01:46:50:07 So this is physiologically getting ready for their role as a dominant territorial male who will, in fact, become able to spawn with the females.
- 123 01:47:01:23 This can happen in a very short time.
- 124 01:47:04:04 In as short as five or six days all of these physiological changes occur.
- 125 01:47:08:06 The opposite, of course, happens when you lose a territory.
- 126 01:47:11:01 The first thing you lose are the bright colorations, but then the cells shrink and the gonads shrink.
- 127 01:47:17:20 And many fish who lose their territories will often go into a shelter, turn on all these signals, pretend they're still dominant.
- 128 01:47:26:00 It's the nearest thing to denial we've seen in fish.
- 129 01:47:29:06 And if they are successful in pretending they're still territorial, they can hang on to the gonads for up to two or three weeks.
- 130 01:47:36:15 >> ZIMBARDO: Fernald's work with model species such as cichlid fish has a surprisingly direct relationship to human behavior.
- 131 01:47:44:23 >> What we've learned is that all of us share a large amount of genomic information.
- 132 01:47:51:06 So, for example, when this animal becomes territorially dominant and turns on a set of genes in the hypothalamus, one of those genes is regulating a peptide which in this fish is 90% identical to the peptide in humans that's turned on at puberty.
- 133 01:48:09:24 So we can look at the human condition and find parallels, and in fact interesting ones.
- 134 01:48:14:29 Perhaps the best described now is something called stress dwarfism.
- 135 01:48:20:26 >> ZIMBARDO: Stress dwarfism was thought to have afflicted James Barrie, the famed author of *Peter Pan* .
- 136 01:48:27:01 Barrie suffered an early childhood trauma over the tragic

death of his only brother, his mother's favored son.

- 137 01:48:35:13 >> The mother went to bed in a Victorian swoon and spent essentially two years in bed.
- 138 01:48:39:25 Each time she saw James, who would come in to talk to her, she'd say, "Oh, dear, it's you, James.
- 139 01:48:44:22 I was hoping Douglas had returned."
- 140 01:48:47:24 James ultimately grew up, but was very short and he spent his life writing books, the best known of which is *Peter Pan* .
- 141 01:48:55:08 All of them have the same theme: a very small person comes into a situation and actually saves the day.
- 142 01:49:01:22 And when James Barrie died, they discovered that he had immature testes.
- 143 01:49:06:13 That is, his testicles had never descended and his small size was undoubtedly caused by this social stress.
- 144 01:49:12:11 Now, this stress dwarfism and concomitant lack of sexual function has to occur only in extreme conditions.
- 145 01:49:19:23 So we have, in fact, a kind of continuity across many species that allow us to imagine we can draw conclusions from these animals that will help us understand different kinds of conditions in humans, both normal and abnormal.
- 146 01:49:35:20 >> ZIMBARDO: Ongoing research like this typically begins with observation of the ordinary behavior of animals in their own natural habitats.
- 147 01:49:44:03 There, researchers explore how and why behavioral strategies are developed to better the odds of survival.
- 148 01:49:51:00 Then it's into the laboratory to answer some questions about the relationship between these changes in behavior essential for the survival of the group and the corresponding changes in the brain and visual system.
- 149 01:50:02:23 In this way, researchers can discover if the brain is responsive to social behavior and how it's modified by experience.
- 150 01:50:19:24 Our final example of the responsive brain driven by behavior comes from another combination of field study and

- laboratory research, this time with baboon colonies in East Africa.
- 151 01:50:35:29 Robert Sapolsky, a Stanford University neurobiologist, is conducting this ongoing research.
- 152 01:50:44:14 >> Probably the most interesting thing about the social structure of baboons is just how social they are.
- 153 01:50:49:18 Basically a baboon makes no sense at all out of the context of its large social troop -- 100, 150 animals all living together years, for decades on end.
- 154 01:50:58:08 And the critical thing about them is who you are in the troop.
- 155 01:51:01:07 Who you are in the dominance hierarchy has everything to do with your quality of life.
- 156 01:51:09:14 It looks as if you get your high rank first, and then your body starts working better.
- 157 01:51:14:07 It looks as if the behavior, the dominant status here among these animals is what drives the physiological changes.
- 158 01:51:21:13 What you wind up wondering then is what is it about suddenly achieving high rank that makes your body function differently, that makes, especially during stress, every aspect of your body work differently?
- 159 01:51:31:23 As far as we can tell and what people know about stress, it has a lot to do with control and predictability.
- 160 01:51:37:16 And for a dominant animal, they have a lot more control over what's going on in their life than a subordinate animal.
- 161 01:51:44:02 >> ZIMBARDO: But Sapolsky also found that the style of dominant behavior among baboons, not just their rank, had a lot to do with their stress level.
- 162 01:51:53:12 Baboons, like humans, will sometimes compete with each other, even when they don't have to.
- 163 01:52:01:17 >> It turns out, if you're a high-ranking baboon, there's a lot of different ways of doing it: having lots of cooperative partners; having none at all; having lots of close, affiliative friendships if you want; having none at all.
- 164 01:52:12:00 And the styles that involve the most social involvement seem

- to have the best physiology.
- 165 01:52:18:03 What's pretty clear is if you study a close relative of ours who has a lot in common with our behavior, you get a lot in common with the physiology.
- 166 01:52:25:00 The striking thing about the baboons is they have a pretty stressful life, but much like ours, it's not stressed because they're starving or there's famines or droughts or whatever.
- 167 01:52:32:20 It's stressful for them because they're pretty tough with each other.
- 168 01:52:36:05 It's a very socially competitive world, much like our own in a lot of ways.
- 169 01:52:40:00 Very few of us are having our stress responses because of ax fights or crop failures or whatever -- most of us because of social reasons.
- 170 01:52:46:15 What's pretty clear from the baboons, in terms of getting at the whole issue of why do some of us get sick, why do some of us get stress-related diseases, what the baboons tell us is there's an awful lot of individual differences there.
- 171 01:52:58:01 Who you are in a baboon society has everything to do with how your body is working.
- 172 01:53:08:09 >> ZIMBARDO: Throughout this program we've seen how research from many disciplines has highlighted the unique capacity of the brain to change itself and its functioning.
- 173 01:53:19:28 The brain responds continually to demands from the environment, which force new behavioral strategies essential for survival.
- 174 01:53:30:10 This research has underscored the basic message of the dynamic, responsive quality of the brain.
- 175 01:53:38:27 In our next program, however, we're going to go back to the beginning, to the start of the human life cycle.
- 176 01:53:45:09 There we'll explore another dynamic responsive entity: the human infant.
- 177 01:53:49:22 Until then, I'm Philip Zimbardo.
- 178 01:53:54:28 [Captioned by The Caption Center WGBH Educational

Foundation]

179 01:54:30:26 >> *Funding for this program is provided by Annenberg/CPB to advance excellent teaching .*

180 01:54:42:02 >> *For information about this and other Annenberg/CPB programs, call 1-800-LEARNER and visit us at*