THE MIND
AND
THE BRAIN
NEUROPLASTICITY
AND THE POWER OF
MENTAL FORCE

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Figure 1: This side view of the brain shows some of its key structures, including those involved in OCD. In the “OCD circuit,” neurons that project from the orbital frontal cortex and the anterior cingulate gyrus to the caudate nucleus are overactive, generating the persistent sense that something is amiss.
Figure 2: Cells in the caudate known as tonically active neurons (TANs) tend to be found between striosomes and matrisomes. Striosomes are areas where information from an emotion-processing part of the brain, the amygdala, reaches the caudate; matrisomes are clumps of axon terminals where information from the thinking, reasoning cerebral cortex reaches the caudate. By virtue of their position, TANs can integrate emotion and thought. They fire in a characteristic pattern when the brain senses something with positive or negative emotional meaning. Cognitive-behavioral therapy may change how TANs respond to OCD triggers.
Figure 3. PET scan showing decreased energy use in the right caudate nucleus (which appears on the left side in a PET scan) in a person with OCD after successful treatment with the Four-Step Method. PRE shows the brain before and POST ten weeks after behavioral therapy with no medication. Note the decrease in “size,” which signifies decrease in energy use, in the right caudate (rCd) after doing the Four-Step Method. The drawings show where the caudate nucleus is located inside the head. (All illustrations reprinted from Brain Lock © 1996 by Jeffrey M. Schwartz)
**Figure 4:** The exertion of willful effort during cognitive-behavioral therapy can activate a “therapy” circuit in the dorsal prefrontal cortex. This can help to override the effects of the OCD circuit.
Figure 5: This neuron is typical of those that project from the cortex to the striatum. The inset shows the critical role that calcium ions play in triggering the release of neurotransmitter from vesicles in the presynaptic neuron into the synapse.
Figure 6: **A.** The sensory homunculus depicts the location and amount of cortical space devoted to processing tactile signals from different places on the body. Sensitive regions such as the lips and genitals command a great deal of cortical space. **B.** The motor homunculus shows the amount of cortical space devoted to controlling the movement of different regions of the body. Muscles involved in speech and hand movements receive a great deal of cortex, while less dextrous regions such as the shoulder receive very little.
Figure 7: The Double-Slit Experiment. Monochromatic light passes through a two-slit grating. In Experiment A, only one narrow slit is open. The narrowness of the slit, coupled with the quantum Uncertainty Principle, causes the beam that passes through the slit to spread out and cover a wide area of the photographic plate. But each photon is observed to land in a tiny spot. The bell curve shows the distribution of spots, or photons. In B, only the right slit is open, and again the beam is spread out over a wide area. In C, both slits are open, but the result is not the sum of the single-slit results (dotted curve). Instead, the photons are observed in narrow bands that resemble the interference pattern formed when water waves pass through two openings in a sea wall: as semicircular waves from the two openings ripple outward, they combine where crest meets crest (in the photon experiment, the bands where many photons are found) and cancel when crest meets trough (where photons are scarce). Opening the second slit makes it clear that light behaves like a wave, since interference is a wave phenomenon. Yet each photon is found to land, whole and undivided, in a tiny region, like a particle would. Even when photons are emitted one at a time, they still form the double-slit interference pattern. Does a single photon interfere with itself?
Quantum Effects of Attention

The rules of quantum mechanics allow attention to influence brain function. The release of neurotransmitters requires calcium ions to pass through ion channels in a neuron. Because these channels are extremely narrow, quantum rules and the Uncertainty Principle apply. Since calcium ions trigger vesicles to release neurotransmitters, the release of neurotransmitter is only probabilistic, not certain. In quantum language, the wave function that represents “release neurotransmitter” exists in a superposition with the wave function that represents “don’t release neurotransmitter”; each has a probability between 0% and 100% of becoming real. Neurotransmitter release is required to keep a thought going; as a result, whether the “wash hands” or “garden” thought prevails is also a matter of probability. Attention can change the odds on which wave function, and hence which thought, wins:

1. In OCD, the brain circuit representing “wash your hands,” for instance, fires over and over. This reflects overactivity in the OCD circuit, which includes the orbital frontal cortex, anterior cingulate gyrus, and caudate nucleus.

2. Therapy introduces the idea that the OCD patient might go to the garden instead of to the sink. This idea activates planning circuits in the brain’s prefrontal cortex. Early in therapy, this circuit is much weaker than the OCD circuit: it has a lower probability of occurring.

3. The vesicle exists as a superposition of quantum wave functions, one representing “release” and one representing “don’t release.” This is true in the brain circuit for washing as well as for gardening.
The OCD patient can now act on this thought and go to the garden. This increases the chance that, in the future, the “garden” circuit will prevail over the “wash” circuit.

By expending mental effort and thus unleashing mental force, however, the OCD patient is able, by virtue of the laws of quantum mechanics, to change the odds. Focusing attention on the “garden” thought increases the probability that neurotransmitter will be released in that circuit, not the “wash” circuit.

The quantum rules allow both states—“release” and “don’t release”—to co-exist. Early in therapy, however, the wave representing “release neurotransmitter” in the OCD circuit has a higher probability than the wave representing “release neurotransmitter” in the garden circuit. The patient is much more likely to go to the sink.

If the patient regularly goes to the garden instead of the sink, neuroplasticity kicks in: brain metabolism changes in a way that strengthens the therapeutic circuit. As a result, future OCD urges are easier to overcome.