Alzheimer’s is a devastating neurodegenerative disease that slowly erases the very thing that makes us who we are—our minds. While major advances in neuroimaging have allowed us to visualize structural, functional and temporal features of the brain in great detail, researchers are limited in their abilities to target specific brain functions. Current interdisciplinary research combining techniques from genetics, biochemistry and photonics to control the functions of single neurons, however, may be the key to unlocking targeted treatments and much more.

Scientists believe a combination of genetic and environmental factors can lead to the neurodegenerative patterns seen in Alzheimer’s. Specifically, the hallmark signs of Alzheimer’s include the buildup of beta-amyloid plaques and neurofibrillary tangles, and the loss of pyramidal neurons in limbic brain regions, i.e., those involved in emotion and memory. These neurodegenerative changes degrade cognitive functions, like the ability to remember a grocery list or recognize someone’s face.

Interestingly, scientists have recently discovered that gamma oscillations, a type of brain wave, behave differently in Alzheimer’s brains. Under normal conditions, gamma oscillations act like a mental heartbeat which synchronizes many of the signals zipping through the brain. In Alzheimer’s brains, gamma oscillations are substantially “quieter”—almost as if someone had pressed the mute button. Until recently, most therapies have focused on the physical set of abnormalities like reducing the buildup of plaque (http://www.alz.org/research/science/alzheimers_treatment_horizon.asp) (made up of beta-amyloid proteins). Very few have looked at turning up gamma oscillations to normal levels—until now.
Researchers at MIT recently loaded light-sensitive proteins into the inter-neurons of transgenic mice exhibiting Alzheimer’s pathology and symptoms using a new technique called optogenetics. Since inter-neurons transmit impulses between other neurons, researchers hoped stimulating the inter-neurons with blue light emitting diodes (LEDs) at 40 flashes per second (40 Hz) would boost the “volume” of gamma oscillations through the stimulated optical beat.

What they found was truly surprising. After just an hour of visual stimulation, the mice demonstrated increased gamma oscillation levels and a remarkable 50 percent reduction in beta-amyloid in the visual cortex—the primary portion of the brain responsible for processing visual input. Turning up the gamma oscillations seemed to wake up microglial cells, which act like the brain’s clean-up crew, to remove the beta-amyloid plaque.

Using light to probe the brain is quickly becoming a rich area of study. In another study, Yale researchers recently demonstrated the optical activation of a mouse’s killer instincts. These experiments used optogenetic techniques to load light-sensitive proteins into neurons located in the amygdala (a section of the brain involved in emotions) that when switched “on” by shining a laser, would make the mouse aggressively attack almost anything, even bottle caps!

Although this field is still in its infancy, the implications of light-based therapies are far reaching. With a direct pathway to the brain, patients may no longer need to depend on chemical treatments. Imagine apps on our phone that could give us our daily dose of gamma signals to prevent the onset of Alzheimer’s all while answering email. Or, spa sessions that include targeted zaps from a laser to treat ailments like anxiety and depression for a true mind and body experience.

As promising as this sounds, we must keep in mind that significant differences exist between mouse and human brains. Although we are still years away from human treatments, research using optogenetics on human neurons is already underway. In fact, scientists have already demonstrated the ability to control human neurons using optogenetics. Perhaps a spa day for your brain isn’t so far-fetched.