For current and future sufferers of Parkinson’s disease, the study of fine motor movement may be a key to unlocking earlier diagnosis and improved treatment regimens.

Parkinson’s disease, a degenerative disorder of the central nervous system, affects about 1 percent over the age of 60 of the world population, or at least 1 million Americans. Parkinson’s patients are typically diagnosed at an average age of 60 years old, while young-onset Parkinson’s disease occurs in 5-10 percent of Parkinson’s patients, who develop symptoms at 40 years of age or younger. Despite the widespread impact of the disease, no biomarker for Parkinson’s currently exists, making diagnosis, especially early diagnosis, especially difficult. Proper diagnosis
requires that patients present two out of the three main symptoms of the disease: tremors at rest, slowness of movement and/or initiation of movement, and rigidity.

“By the time Parkinson’s patients are normally diagnosed, nearly 80 percent of their normal dopamine levels are depleted,” said Arend Van Gemmert assistant professor in the School of Kinesiology and director of the Fine Motor Control and Learning Laboratory.

 Parkinson’s disease is characterized by abnormal death of cells in the substantia nigra, a region of the midbrain responsible for producing adequate levels of the neurotransmitter dopamine. Dopamine is a neurotransmitter that helps control the brain’s reward and pleasure centers and regulates movement and emotional responses. Dopamine deficiency in Parkinson’s patients causes the characteristic movement disorders observed in the disease. However, because large-scale movement deteriorations are not observed in Parkinson’s patients until dopamine levels are substantially depleted, there is a push in research on the disease to develop techniques for earlier diagnosis.

Van Gemmert is hot on this trail, working to develop methods for the characterization of fine motor function changes in Parkinson’s patients using handwriting. By investigating the fine motor movement changes associated with Parkinson’s, as opposed to the typical large-scale movement disorders that affect patients in later stages of the disease, Van Gemmert and his team may be unlocking a method for earlier diagnosis and therapeutic evaluation.

“I am interested in fine motor function, in particular fine motor skills performed

with the hands,” Van Gemmert said. “My analysis of handwriting is not like what people normally think about when they hear analysis of handwriting – I am not looking at personality or other characteristics commonly associated with handwriting. I am using handwriting as a tool to investigate how fine motor function is affected by situations including stress, aging and movement disorders, in particular Parkinson’s disease.”

Van Gemmert investigates how the fingers and wrist coordinate to produce fine movements, and how this coordination is affected by illnesses such as Parkinson’s disease. He and his team use a computerized writing tablet and custom mathematical algorithms in order to extract information on accelerations and decelerations in an individual’s handwriting, and use this information to estimate the forces required in writing.
Handwriting is a communication skill that requires acceleration of the tip of the pen rapidly and accurately over the surface of the paper,” Van Gemmert and colleagues wrote in a related research paper. “An important feature of proficient handwriting is that acceleration needs to be accurately modulated to keep the writing legible.”

In his own research, Van Gemmert has found supporting evidence for changes in handwriting among Parkinson’s patients when compared to people of similar ages without Parkinson’s disease. Van Gemmert and other researchers have recognized micrographia, or abnormally small, cramped handwriting, as a symptom of the disease, where 10-15 percent of Parkinson’s patients have been observed clinically to write progressively smaller than the average handwriting height of 0.8 centimeters. While only one other research group has shown evidence that micrographia occurs before a Parkinson’s disease diagnosis can be typically be made, Van Gemmert has observed patients often claim that they noticed this symptom looking back after diagnosis.

“I am hoping we can use this technique in the future to help diagnose Parkinson’s patients and to help determine appropriate doses of current therapeutics,” Van Gemmert said.

In his research, Van Gemmert has also shown that Parkinson’s patients have trouble drawing big letters, especially when asked to write quickly. In handwriting analysis experiments, Van Gemmert and his team observed that when challenged to write letters of a particular size, Parkinson’s patients have more trouble accomplishing the task than individuals of a similar age without Parkinson’s disease. This is because Parkinson’s patients have trouble producing the modulated forces required during the acceleration and deceleration phases of handwriting. As a result, they display “jerky” handwriting. Also, in trying to write smoothly in a laboratory setting, Parkinson’s patients often write smaller and push harder on the pen.

“Handwriting is a very good model for fine motor movements,” Van Gemmert said. “I use handwriting-like movements to measure displacement and axial pen pressure. These measures can then be used to calculate velocity, acceleration and jerk. These measures and other derived measures can be used to infer coordination between the arm, wrist and fingers when performing a fine motor task. With our measurements, we can show if an individual writes faster or slower, with more or less pressure, and more or less smoothly than normal. These changes can occur due to stress, disease or the difficulty of the task.”
From maneuvering buttons on clothing to writing a check, disruptions in fine motor movements can affect Parkinson’s patients early in the course of the disease. Van Gemmert hopes that handwriting analysis can become a go-to tool for helping diagnose Parkinson’s disease and provide patients with adequate levels of dopaminergic therapeutics. However, he warns, handwriting analysis must be paired with other more traditional diagnostic tools in order to be effective in helping diagnose Parkinson’s disease. Before micrographia can be evaluated as a clinical symptom of the disease, researchers must also show that smaller-than-average handwriting is not a side effect of other Parkinson-like nervous disorders.

Van Gemmert and his team also study bilateral transfer of learning in Parkinson’s patients and how stress affects motor movement. Through his work on fine motor movement analysis, Van Gemmert is improving our ability to investigate how various illnesses affect movement centers of the brain.

“In 5-10 years, I hope that we can start having clinical trials using relatively inexpensive digitizer tablets or even iPads/PC tablets, improving the monitoring of treatment effectiveness and to help with the early diagnosis of probable Parkinson’s disease,” said Van Gemmert. “Also, I hope that my research, in general, increases our knowledge about the involvement of basal ganglia in the planning and execution of fine motor skills. If we have a better understanding of this, maybe researchers will find better treatments to target the disease and/or to alleviate the disabling symptoms associated with Parkinson’s.”

These screenshots are from the analysis program developed at the Polytechnique University Montreal in the lab of Réjean Plamondon, and researchers at LSU can use it because of a collaboration agreement between the two universities initiated by Plamondon and LSU’s Arend Van Gemmert.

The first screenshot is of an individual with Parkinson’s disease. Notice the number of green velocity impulses needed to make a single letter l. Also, the actual velocity does not show bell shaped profiles, so although the written traces do not look terrible, the fingers and wrist do not efficiently move the tip of the pen over the surface.

The second screenshot is of an older individual (over 60). Notice that the number of green velocity impulses are still high, but most of the velocity impulses are just small corrections (so they have small amplitudes). The dark blue profile shows much more bell shaped velocity profiles again indicating much more efficient use of the fingers and wrist to propel the pen over the surface.

The third screenshot is of a young adult. Notice that there are much less green impulse velocity profiles. Each dark blue velocity peak is built by just a single velocity impulse, so the tip of the pen is very efficiently moved by the fingers and wrist over the surface.