we get to nilpotency classes higher than that, things start getting much trickier.

My research this summer was to begin work specifically on the Lie ring M_5. The module is generated by $x_0, x_1, x_2, x_3, x_4, x_5$ such that x_i $i \neq 0, 5$ $[x_0, x_i] = x_{i+1}$ with all other brackets commuting i.e. equaling zero. While the work is not yet completed, so far conditions have been found for all elements other than p^{a_0}.

Power-Law Correlations in Wrist Actigraphy Data of Healthy Subjects and Patients with Traumatic Brain Injury

Mark Kaplan
Chana Tropp
Advised under Dr. Ronny Bartsch

Human motor activity is inherently complex, being affected by numerous factors both extrinsic (normal physical activity, sports, response to random events) and intrinsic (the circadian rhythm, sleep/wake cycles). Traditionally, the output signals of motor activity such as wrist actigraphy data have been considered as random noise and often ignored. However, recent studies have found long-range power-law correlations and nonlinear features in such data, which are consistent among healthy individuals (independent of their activity level) but break down in patients with Alzheimer's disease. These findings indicate that human activity control may be based on a multiple-component nonlinear feedback mechanism encompassing coupled neuronal nodes located in the central and peripheral nervous systems. Moreover, the results also suggest that statistical physics measures that quantify power-law correlations and nonlinear properties could be used as diagnostic markers and to monitor treatment for patients with neurodegenerative diseases or acute injuries of the central/peripheral nervous system.

The overall goal of our project is to investigate statistical physics measures that characterize scaling and correlation properties of actigraphy fluctuations in order to monitor the rehabilitation of patients with Traumatic Brain Injury (TBI). The project also includes the long-term recording of actigraphy data (~7-10 days) from several healthy subjects and patients before and after treatment. This is an interdisciplinary project that combines the application of advanced physics methods for data analysis with long-term recording at the BIU Physics Department and work with medical doctors and clinicians at Sheba Medical Center to record the data.

Since human activity is largely influenced by the central nervous system, we hypothesize that patients suffering from Traumatic Brain Injury (TBI) would show different activity patterns as a result of their injury. To address this hypothesis, we recorded data from healthy subjects (n=2) as well as patient with TBI (n=2). Moreover, we developed computer programs for data analysis to utilize, for example, the detrended fluctuation analysis (DFA). Detrended fluctuation analysis is a method used to determine the self-affinity of a signal. The DFA produces an exponent, α, which indicates the correlation, or conversely the randomness, of a certain signal. Before applying the programs to analyze the physiological data, we performed tests on artificially generated surrogate data using the Fourier-filtering method .

Figure 1a shows an example of wrist actigraphy data of a healthy subject recorded continuously over 7 consecutive days of normal activity. The DFA exponent α for this data is 1.0 (Fig. 1c), a value that corresponds to 1/f behavior, which is characteristic for healthy human motor activity. Shuffling the data and hence destroying any correlations, yields $\alpha = 0.5$ (Fig. 1b and Fig. 1c, green curve). In Fig. 2 we depict the data of one TBI patient. Data was analyzed separately for each

24h period and sorted by the overall level of activity during those days. Note that despite the significant difference in the activity levels for different days, the DFA exponent α is unaffected and shows a almost constant value of $\alpha = 0.8$ (which is lower as compared to the DFA exponent $\alpha = 1.0$ of the healthy subject).

In conclusion, our analysis shows that DFA is a suitable method to quantify correlations in human actigraphy data, independent of the level of overall activity. Unfortunately, our data base of 2 healthy and 2 TBI patients is not sufficient to address our hypothesis and to show a significant difference in the DFA exponents between these two groups. More data need to be recorded, which will be done during the next months, however, it is beyond the time frame of this program. Additionally, the TBI patients will be measured again after undergoing a extensive rehabilitation program at Sheba Medical Center, and our research could be applied to quantitatively evaluate and assess the benefits of such rehabilitation therapy. Moreover, it may be suitable also for other patients who experience difficulties in controlling their limbs, such as after stroke or in patients with muscle spasms.

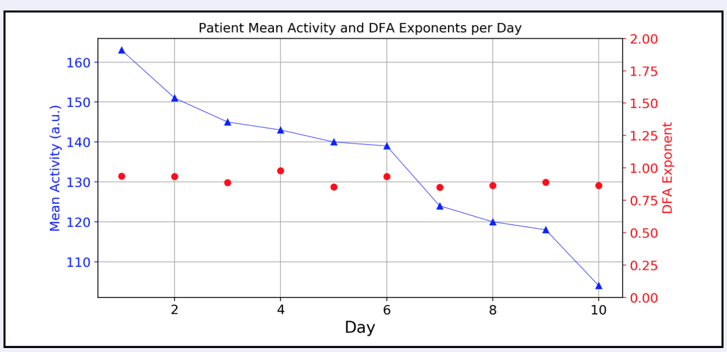
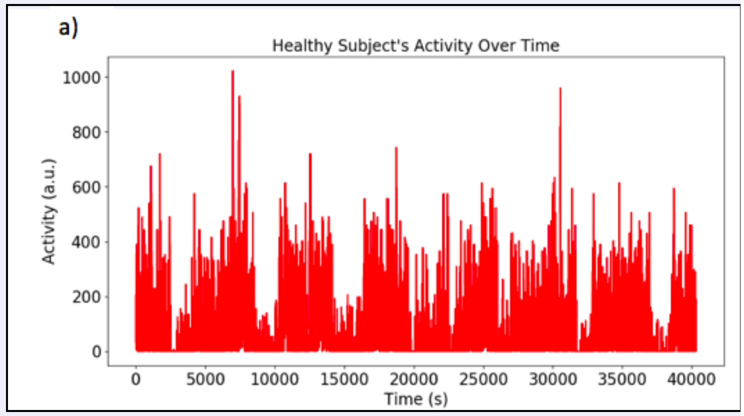
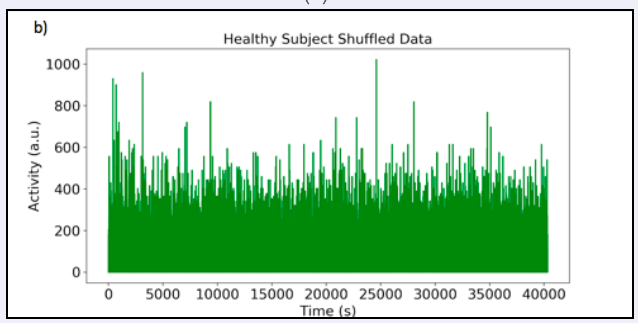


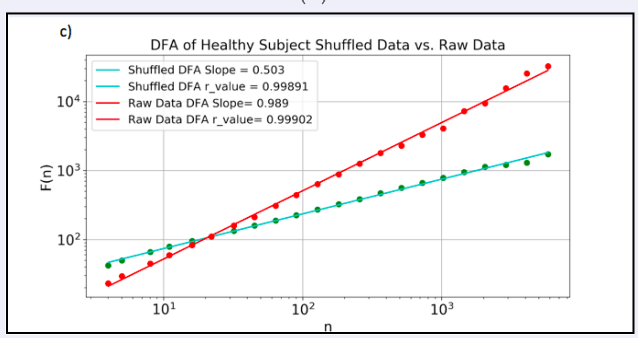
Figure 2: Mean wrist actigraphy data for TBI patient (blue) per day, ordered by activity level (highest to lowest) with DFA exponents of the corresponding days (red). The correlation properties remain constant regardless of activity level.



(a)



(b)



(c)

Figure 1: Wrist actigraphy data for one healthy subject recorded over 7 days and DFA analysis. The raw data for 7 consecutive days are shown in Fig. 1a. Note the patterns of high activity during light periods, alternating with patterns of low activity during the nights. Applying DFA on the raw data yields an exponent of 1.0 (red curve in Fig. 1c). After shuffling the raw data of Fig. 1a, activity patterns and correlation properties are lost (Fig. 1b) and data show characteristics of white noise with DFA exponent of 0.5 (green curve in Fig.1c).