CHAPTER IV

DATA COLLECTING AND PROCESSING

4.1 DATA COLLECTION

The data collection on this research is about respondent's profile, raw data of EEG signals, and final score of study based on 10 questions offered.

4.1.1 RESPONDENT PROFILE

The respondent's profile was measured by direct measurement. Four students have been participated as described in Table 4.1 below

Table 4.1 Respondent Profile

Respondent	Age (years old)	Gender	Interest on Physics	Physics Score	Neurological problems	Psychiatric Mental Problems
1	17	Male	Like	80	-	-
2	17	Male	Like	84	-	-
3	18	Female	Like	82	-	-
4	17	Female	Like	80	-	-

Based on data collection, there were 4 students participated in this study in the range age of 17 to 18 years old. The interest point and score of Physic subject has been identified to get a uniform background of research subject. They liked physics subject which their physics score

was above minimum completeness criteria score set by school (68) which is in range 80 to 84. Then, all respondents had no neurological and psychiatric mental problems, had no experience in smoking, abstained from caffeine for 12 hours, had a full night's sleep before the experiment, and like the Physics subject.

Respondent 1 and 3 learn the Physics by autodidact in the late morning for the first session of experiment day, non-autodidact in the afternoon for the second session, non-autodidact in the late morning for the third session, and autodidact in the afternoon for the last session. Meanwhile, respondent 2 and 4 learn the Physics by non-autodidact in the late morning for the first session of experiment day, autodidact in the afternoon for the second session, autodidact in the late morning for the third session, and non-autodidact in the afternoon for the last session.

4.1.2   EEG SIGNAL INTEPRETATION

EEG signal interpretation was done using software OpenBCI GUI 2.1.1 and Matlab R2016a. Software OpenBCI GUI 2.1.1 was used in visualizing, recording, and streaming data. It is shown in Figure 4.1 below.
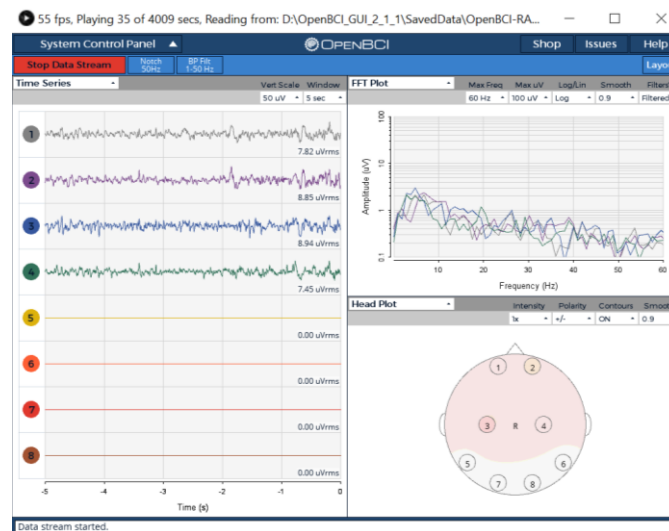
Figure 4.1 Display of OpenBCI GUI 2.1.1

Meanwhile Matlab 2016 was used in processing the data and visualizing full time EEG raw data, full time EEG final data, precise time EEG final data, and calculating RMS.

In recording brain activity, variable used in this study is learning method and condition which were autodidact in the late morning, autodidact in the afternoon, non-autodidact in the late morning, and non-autodidact in the afternoon. Four electrodes of Sn were placed at F3, F4, P3, and P4. It was recorded whereas reference electrode was placed at the right and left ear lobes. Moreover, the sampling frequency was kept at 200 Hz and the skin impedance was below 19 kΩ stated as low impedance. Li et al., (2016) revealed that magnitude and stability of the electrode-skin impedance determines the quality of EEG signals. Low and stable electrode-skin impedance can minimize the impedance mismatch, which helps to reduce the powerline interference.
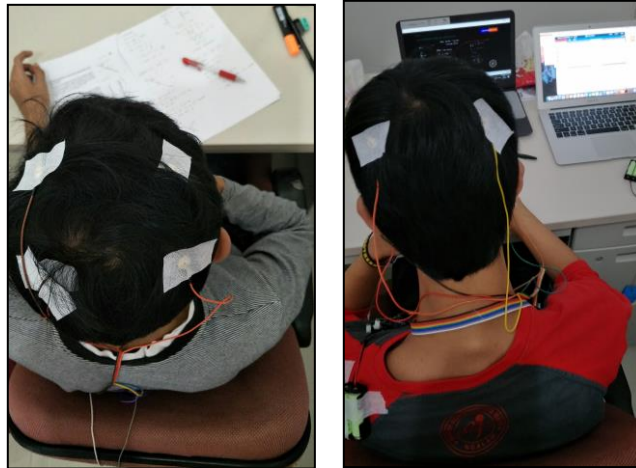
Figure 4.2 Brain Wave Recording Using Electroencephalograph

4.1.3 EEG RAW SIGNAL

EEG raw data is EEG signal recorded during experiment by OpenBCI GUI 2.1.1 without any signal process. It had some noise or unwanted signal by system. Those were EEG raw signal recorded on 4 session which were autodidact in the late morning, autodidact in the afternoon, non-autodidact in the late morning, and non-autodidact in the afternoon.

4.1.3.1 EEG Raw Signal of Autodidact in the Late Morning

First session of experiment was autodidact in the late morning session. It was conducted at 09.00 where respondent was asked to read sub-chapter of Physics (Electromagnetic Induction) as autodidact learning method. One of the raw brain wave recorded by EEG for 90 minutes in this session are shown in Figure 4.3 below.
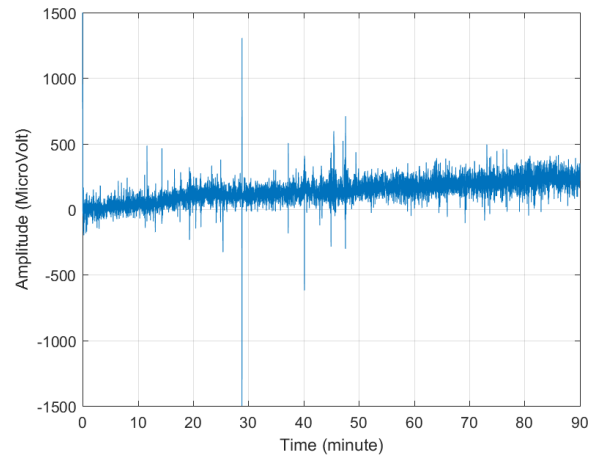
Figure 4.3 Raw Signal of Autodidact in the Late Morning

4.1.3.2   EEG Raw Signal of Autodidact in the Afternoon

Second session of experiment was autodidact in the afternoon session. It was conducted at 13.00 where respondent was asked to read sub-chapter of Physics (Electromagnetic Induction) as autodidact learning method. One of the raw brain wave recorded by EEG for 90 minutes in this session are shown in Figure 4.4 below.
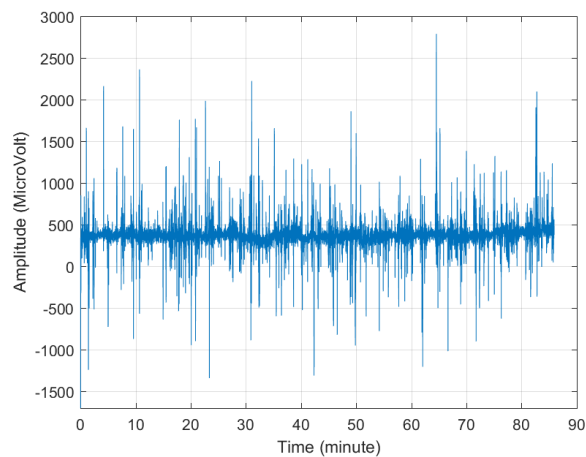

Figure 4.4 Raw Signal of Autodidact in the Afternoon

4.1.3.3   EEG Raw Signal of Non-Autodidact in the Late Morning

Third session of experiment was non-autodidact in the late morning session. It was conducted at 09.00 where respondent was asked to watch a video showing someone explains sub-chapter of Physics (Electromagnetic Induction) on blackboard as non-autodidact learning method. One of the raw brain wave recorded by EEG for 90 minutes in this session are shown in Figure 4.5 below.
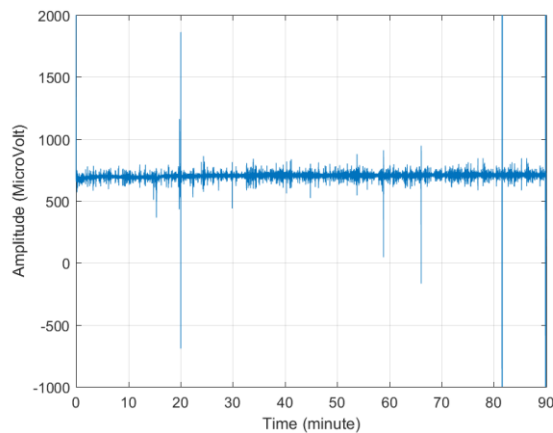

Figure 4.5 Raw Signal of Non-Autodidact in the Late Morning

4.1.3.4   EEG Raw Signal of Non-Autodidact in the Afternoon

Fourth session of experiment was non-autodidact in the afternoon session. It was conducted at 13.00 where respondent was asked to watch a video showing someone explains sub-chapter of Physics (Electromagnetic Induction) on blackboard as non-autodidact learning method. One of the raw brain wave recorded by EEG for 90 minutes in this session are shown in Figure 4.6 below.
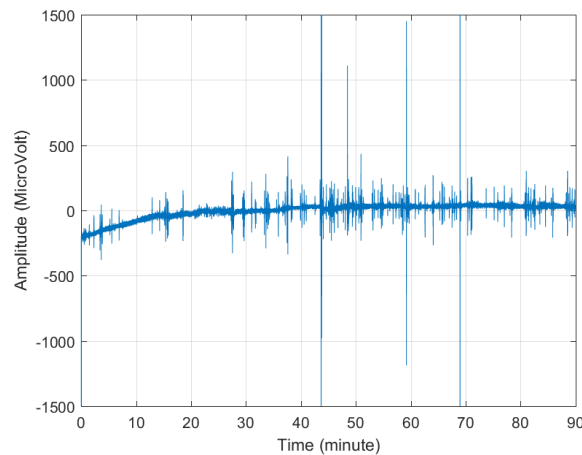
Figure 4.6 Raw Signal of Non-Autodidact in the Afternoon

4.1.4   SCORE OF STUDY

Score of study was gotten based on the correct answer toward 10 question. Table 4.2 below shows the score of Physic subject especially on Electromagnetic Induction subchapter by using two methods and different conditions in teaching learning process.

Table 4.2 Result of Score

Respondent	Autodidact		Non-autodidact	
	Late Morning	Afternoon	Late Morning	Afternoon
S1	60	50	30	20
S2	80	70	70	70
S3	60	50	60	30
S4	70	40	50	40
Average	67.5	52.5	52.5	40

4.2   DATA PROCESSING

The data that would be processed which is EEG raw data. It was processed using Notch and Bandpass by Matlab R2016a to get desired final data. The calculation of RMS should be

done by seeing Theta, Alpha, and Beta of each channel to get early time of respondent for getting mental fatigue. Wilcoxon Signed Rank test was done as non-parametric statistic.

4.2.1 EEG FINAL SIGNAL

Notch filter was used to reject narrow frequency at 49-51 Hz for rejecting noise due to electrical problems and leaves the rest frequency. Band pass filter was used to select frequency from EEG data that would be used which is theta (4-8 Hz), alpha (8-13 Hz), and beta (13-30 Hz). Notch and band pass filter is processed using Matlab R2016a.

4.2.1.1 Theta

Theta waves lie within the range of 4 – 8 Hz. Theta waves appear as consciousness slips toward drowsiness (Sanei & Chambers, 2007). One of the final brain wave on lower frequency (theta) that had been processed through notch and band pass filter are shown in Figure 4.7 below.
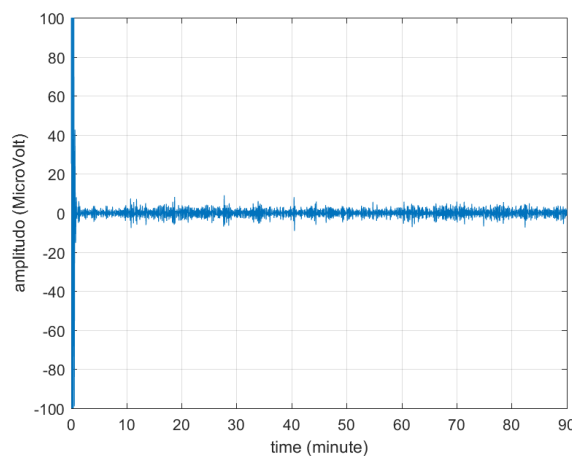
Figure 4.7 Final Signal of EEG on Theta Wave

4.2.1.2   Alpha

Alpha waves have frequency within the range of 8-13 Hz. It has been thought to indicate both a relaxed awareness without any attention or concentration. (Sanei & Chambers, 2007). One of the final brain wave on middle frequency (alpha) that had been processed through notch and band pass filter are shown in Figure 4.8 below.
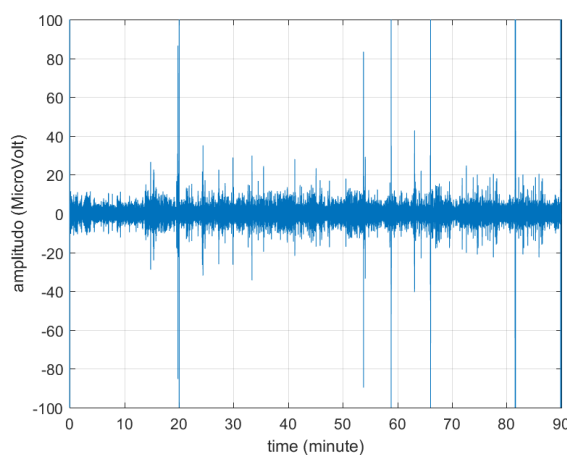

Figure 4.8 Final Signal of EEG on Alpha Wave

4.2.1.3   Beta

A beta waves is the electrical activity of the brain varying within the range of 13-30 Hz. A beta wave is the usual waking rhythm of the brain associated with active thinking, active attention, focus on the outside world, or solving concrete problems (Sanei & Chambers, 2007). One of the final brain wave on higher frequency (beta) that had been processed through notch and band pass filter are shown in Figure 4.9 below.
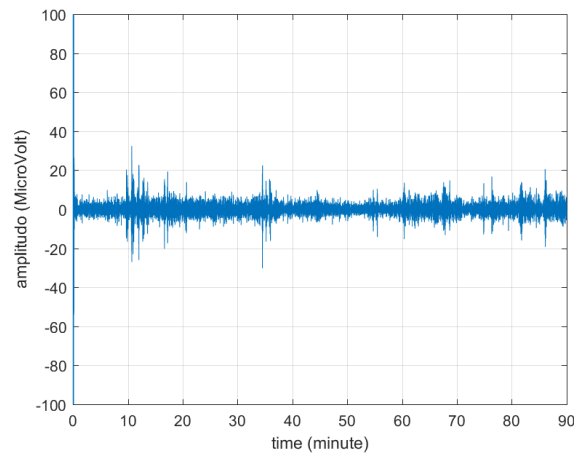
Figure 4.9 Final Signal of EEG on Beta Wave

4.2.2   RMS CALCULATION

Calculation of RMS was done using formula on equation 3.1 that is used on final signal of EEG on each wave for every channels and sessions. It was used in order to see the shift of amplitude on Theta, Alpha, and Beta wave.

4.2.2.1   Autodidact in the Late Morning

a.   Respondent 1

Figure 4.10 shows the amplitude RMS graphic of first respondent's EEG final signal on autodidact in the late morning at F3 channel. It shows that amplitude of Beta was greater than Theta and Alpha at the 49th minute, where the value of Beta, Theta, and Alpha was 9.8041, 6.1997, and 7.1509 µv at the 49th minute. Then, the amplitude of Theta (9.3048 µv) at 50th minute increased and was always greater than amplitude of Alpha (6.1748 µv) and Beta (7.4560 µv).
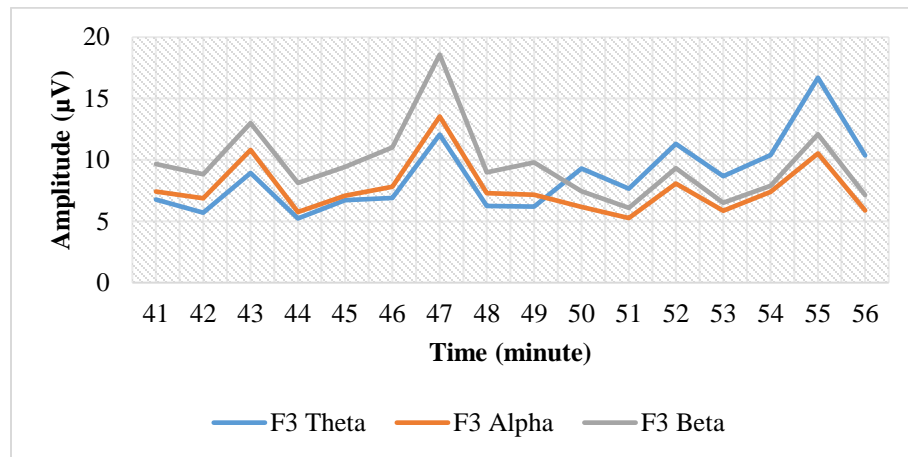
Figure 4.10 RMS Graphic on Respondent 1 at F3 by autodidact in the late morning

Figure 4.11 shows the amplitude RMS graphic of first respondent's EEG final signal on autodidact in the late morning at F4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at 49th minute, where the value of Beta, Theta, and Alpha was 7.2753, 4.5984, and 4.9640 µv at 49th minute. Then, the amplitude of Theta (7.1210 µv) at the 50th minute increased and was always greater than amplitude of Alpha (4.7321 µv) and Beta (5.0803 µv).
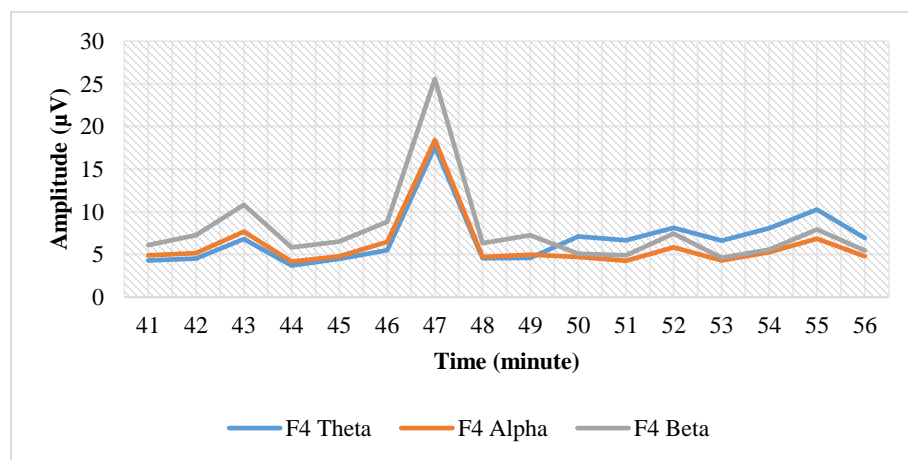

Figure 4.11 RMS Graphic on Respondent 1 at F4 by autodidact in the late morning

Figure 4.12 shows the amplitude RMS graphic of first respondent's EEG final signal on autodidact in the late morning at P3 channel. It shows that amplitude

of Beta was greater than Theta and Alpha until at the 49th minute, where the value of Beta, Theta, and Alpha was 10.4770, 7.0459, and 7.5706 µv at the 49th minute. Then, the amplitude of Theta (9.5060 µv) at the 50th minute increased and was always greater than amplitude of Alpha (6.1465 µv) and Beta (6.8946 µv).
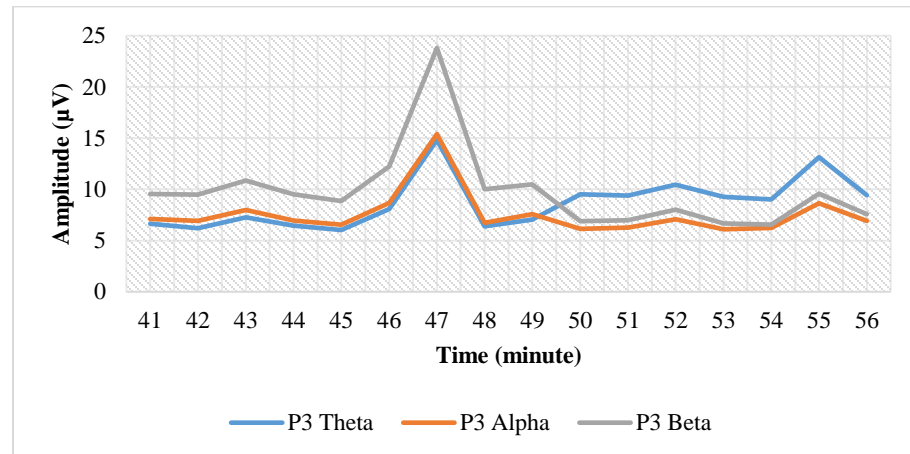

Figure 4.12 RMS Graphic on Respondent 1 at P3 by autodidact in the late morning

Figure 4.13 shows the amplitude RMS graphic of first respondent's EEG final signal on autodidact in the late morning at P4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 49th minute, where the value of Beta, Theta, and Alpha was 11.3584, 7.3836, and 7.9585 µv at the 49th minute. Then, the amplitude of Theta (10.8446 µv) at the 50th minute increased and was always greater than amplitude of Alpha (6.8895 µv) and Beta (8.0442 µv).
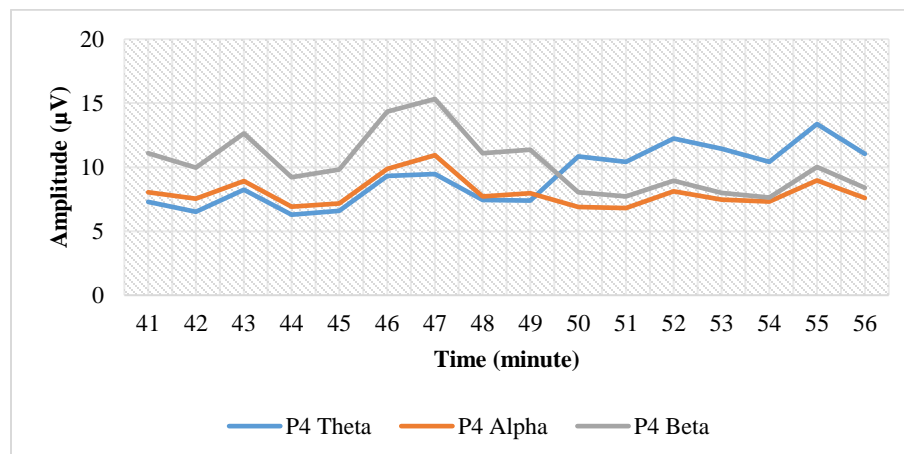
Figure 4.13 RMS Graphic on Respondent 1 at P4 by autodidact in the late morning

Based on Figure 4.10 and Figure 4.11, the ability of respondent 1 to memorize and solve problems appeared until at the 49th minute. Then at the 50th minute, it decreased and respondent 1 felt sleepy. As well as shown on Figure 4.12 andFigure 4.13, the ability of respondent 1 to read and understand the lesson appeared until at the 49th minute. Then at the 50th minute, it decreased and respondent 1 felt sleepy. It indicated that respondent 1 had not focussed on Physics subject at the 50th minute during studying on autodidact in the late morning.

b.   Respondent 2

Figure 4.14 shows the amplitude RMS graphic of second respondent's EEG final signal on autodidact in the late morning at F3 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 47th minute, where the value of Beta, Theta, and Alpha was 6.4773, 4.7371, and 4.7020 µv at the 47th minute. Then, the amplitude of Theta (23.3589 µv) at the 48th minute increased and was greater than amplitude of Alpha (15.8789 µv) and Beta (16.1328 µv).
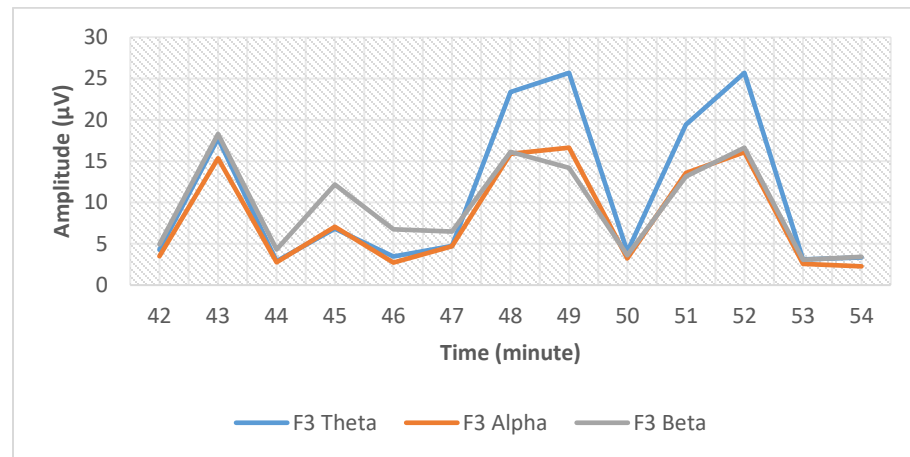
Figure 4.14 RMS Graphic on Respondent 2 at F3 by autodidact in the late morning

Figure 4.15 shows the amplitude RMS graphic of second respondent's EEG final signal on autodidact in the late morning at F4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 47th minute, where the value of Beta, Theta, and Alpha was 6.2958, 5.2052, and 5.0360 µv at the 47th minute. Then, the amplitude of Theta (19.0338 µv) at the 48th minute increased and was greater than amplitude of Alpha (14.1183 µv) and Beta (14.8774 µv).
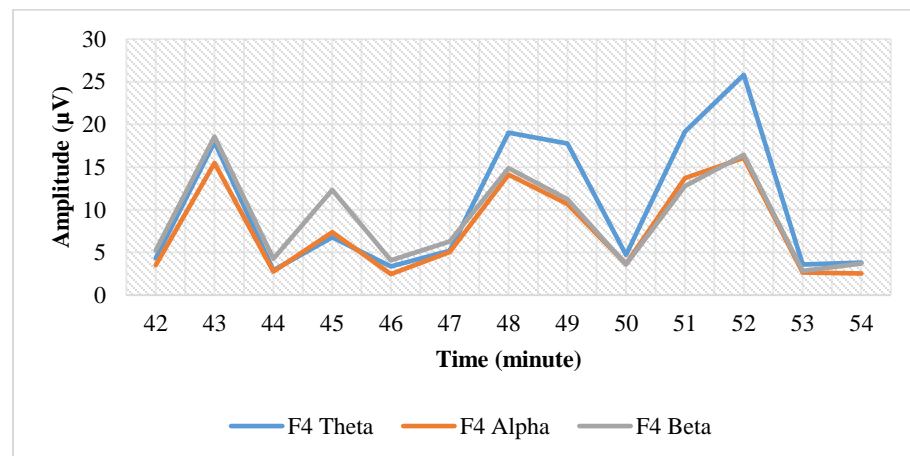

Figure 4.15 RMS Graphic on Respondent 2 at F4 by autodidact in the late morning

Figure 4.16 shows the amplitude RMS graphic of second respondent's EEG final signal on autodidact in the late morning at P3 channel. It shows that amplitude

of Beta was greater than Theta and Alpha until at the 47th minute, where the value of Beta, Theta, and Alpha was 6.3741, 4.4054, and 5.0326 µv at the 47th minute. Then, the amplitude of Theta (18.9129 µv) at the 48th minute increased and was greater than amplitude of Alpha (14.1392 µv) and Beta (14.9572 µv).
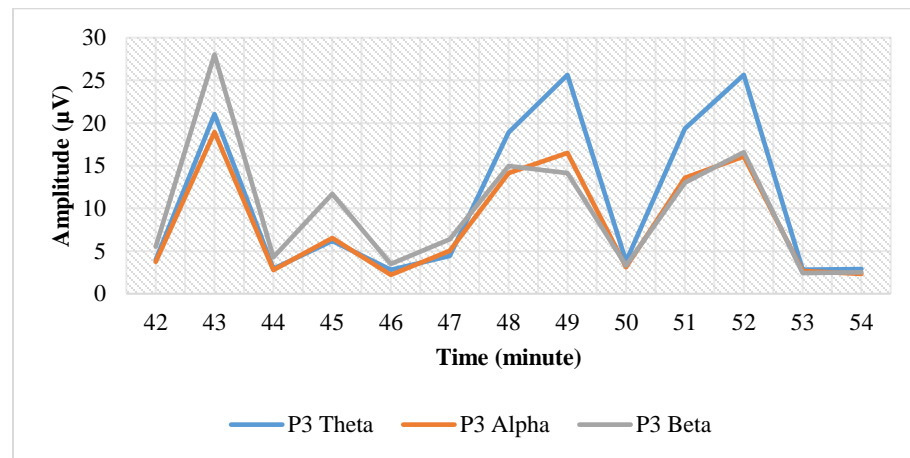

Figure 4.16 RMS Graphic on Respondent 2 at P3 by autodidact in the late morning

Figure 4.17 shows the amplitude RMS graphic of second respondent's EEG final signal on autodidact in the late morning at P4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 47th minute, where the value of Beta, Theta, and Alpha was 6.4194, 4.8581, 5.2492 µv at the 47th minute. Then, the amplitude of Theta (23.3340 µv) at the 48th minute increased and was greater than amplitude of Alpha (15.8709 µv) and Beta (16.0710 µv).
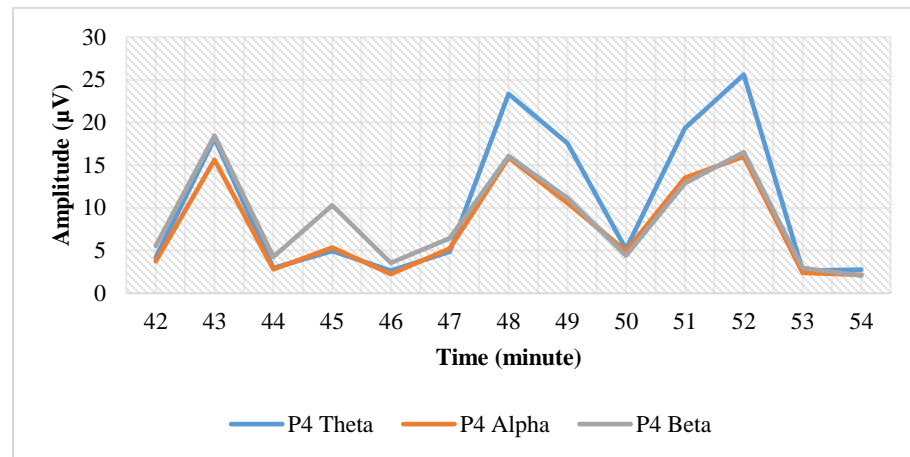
Figure 4.17 RMS Graphic on Respondent 2 at P4 by autodidact in the late morning

Based on Figure 4.14 and Figure 4.15, the ability of respondent 2 to memorize and solve problems appeared until at the 47th minute. Then at the 48th minute, it decreased and respondent 2 felt sleepy. As well as shown on Figure 4.16 and Figure 4.17, the ability of respondent 2 to read and understand the lesson appeared until at the 47th minute. Then at the 48th minute, it decreased and respondent 2 felt sleepy. It indicated that respondent 2 had not focussed on Physics subject at the 48th minute during studying on autodidact in the late morning.

c.   Respondent 3

Figure 4.18 shows the amplitude RMS graphic of third respondent's EEG final signal on autodidact in the late morning at F3 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 60th minute, where the value of Beta, Theta, and Alpha was 5.4165, 3.9254, and 4.1439 µv at the 60th minute. Then, the amplitude of Theta (12.7279 µv) at the 61st minute increased and was always greater than amplitude of Alpha (9.4935 µv) and Beta (9.3499 µv).
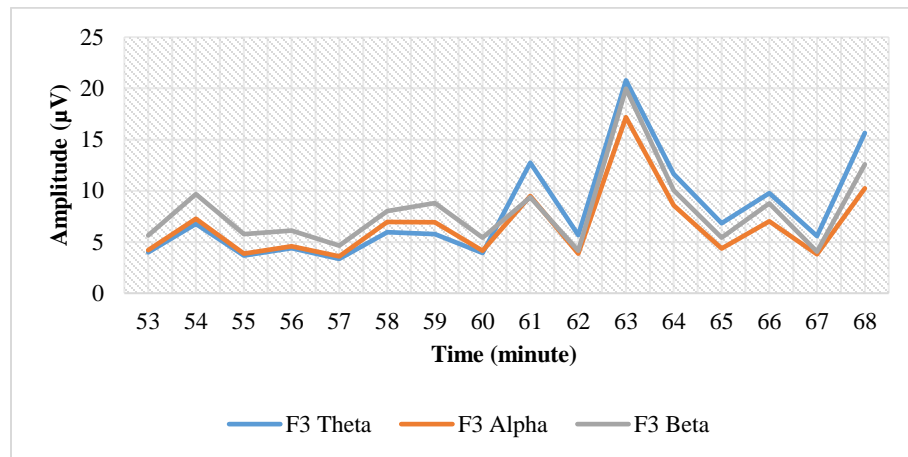
Figure 4.18 RMS Graphic on Respondent 3 at F3 by autodidact in the late morning

Figure 4.19 shows the amplitude RMS graphic of third respondent's EEG final signal on autodidact in the late morning at F4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 60th minute, where the value of Beta, Theta, and Alpha was 6.2417, 4.5828, and 4.5879 µv at the 60th minute. Then, the amplitude of Theta (8.0840 µv) at the 61st minute increased and was always greater than amplitude of Alpha (6.1066 µv) and Beta (6.4558 µv).

Figure 4.19 RMS Graphic on Respondent 3 at F4 by autodidact in the late morning

Figure 4.20 shows the amplitude RMS graphic of third respondent's EEG final signal on autodidact in the late morning at P3 channel. It shows that amplitude

of Beta was greater than Theta and Alpha until at the 60th minute, where the value of Beta, Theta, and Alpha was 6.9863, 4.6606, and 5.1101 µv at the 60th minute. Then, the amplitude of Theta (7.2938 µv) at the 61st minute increased and was always greater than amplitude of Alpha (5.1226 µv) and Beta (5.6448 µv).
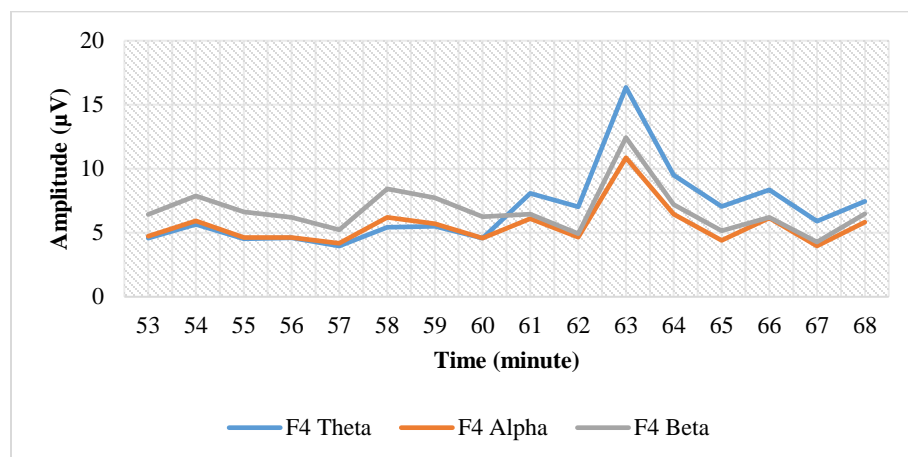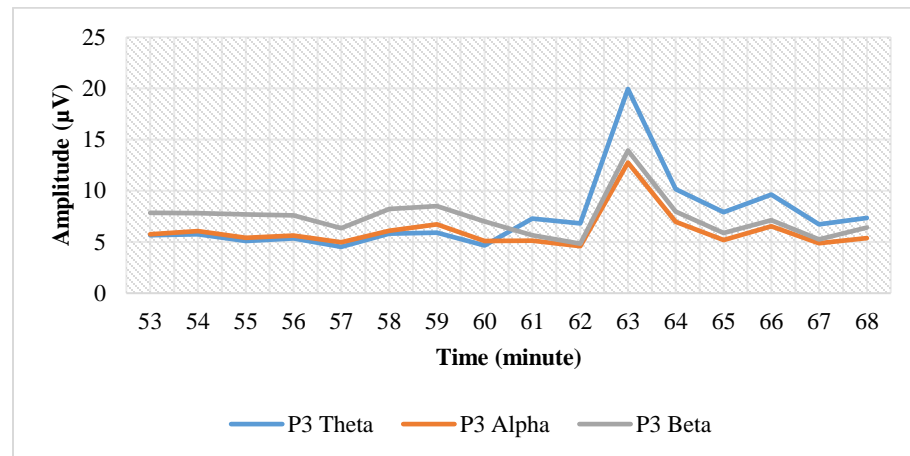

Figure 4.20 RMS Graphic on Respondent 3 at P3 by autodidact in the late morning

Figure 4.21 shows the amplitude RMS graphic of third respondent's EEG final signal on autodidact in the late morning at P4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 60th minute, where the value of Beta, Theta, and Alpha was 7.4726, 5.4912, and 5.7120 µv at the 60th minute. Then, the amplitude of Theta (8.4547 µv) at the 61st minute increased and was always greater than amplitude of Alpha (6.1470 µv) and Beta (6.5695 µv).
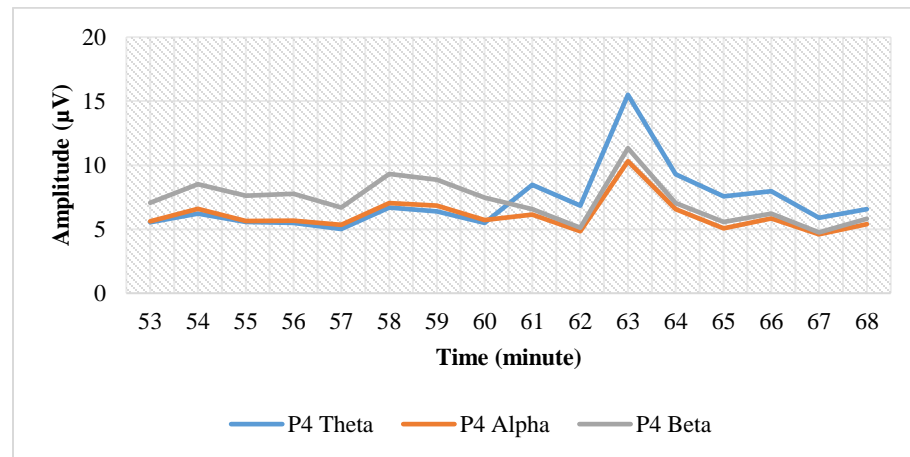
Figure 4.21 RMS Graphic on Respondent 3 at P4 by autodidact in the late morning

Based on Figure 4.18 and Figure 4.19, the ability of respondent 3 to memorize and solve problems appeared until at the 60th minute. Then at the 61st minute, it decreased and respondent 3 felt sleepy. As well as shown on Figure 4.20 and Figure 4.21, the ability of respondent 3 to read and understand the lesson appeared until at the 60th minute. Then at the 61st minute, it decreased and respondent 3 felt sleepy. It indicated that respondent 3 had not focussed on Physics subject at the 61st minute during studying on autodidact in the late morning.

d.   Respondent 4

Figure 4.22 shows the amplitude RMS graphic of fourth respondent's EEG final signal on autodidact in the late morning at F3 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 57th minute, where the value of Beta, Theta, and Alpha was 6.0242, 4.2019, and 5.0901 µv at the 57th minute. Then, the amplitude of Theta (7.2003 µv) at the 58th minute increased and was greater than amplitude of Alpha (5.0558 µv) and Beta (5.6945 µv).

Figure 4.22 RMS Graphic on Respondent 4 at F3 by autodidact in the late morning

Figure 4.23 shows the amplitude RMS graphic of fourth respondent's EEG final signal on autodidact in the late morning at F4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 57th minute, where the value of Beta, Theta, and Alpha was 6.6859, 4.6894, and 5.3609 µv at the 57th minute. Then, the amplitude of Theta (7.4391 µv) at the 58th minute increased and was greater than amplitude of Alpha (5.1884 µv) and Beta (5.6915 µv).
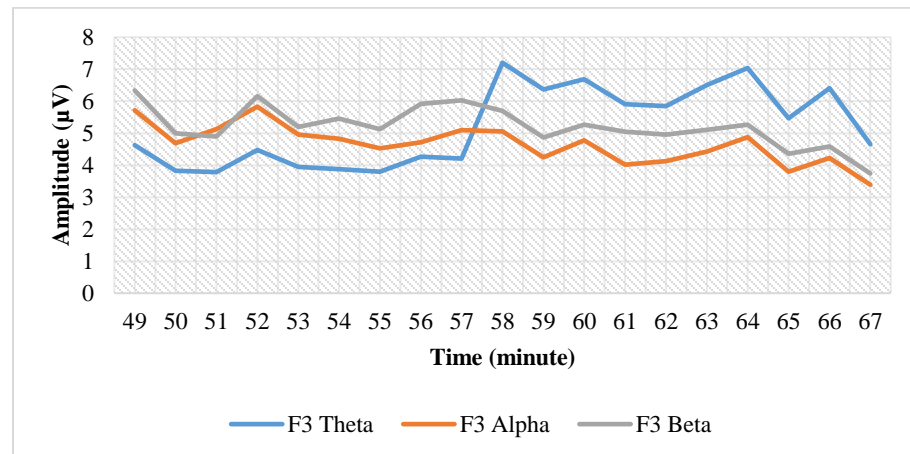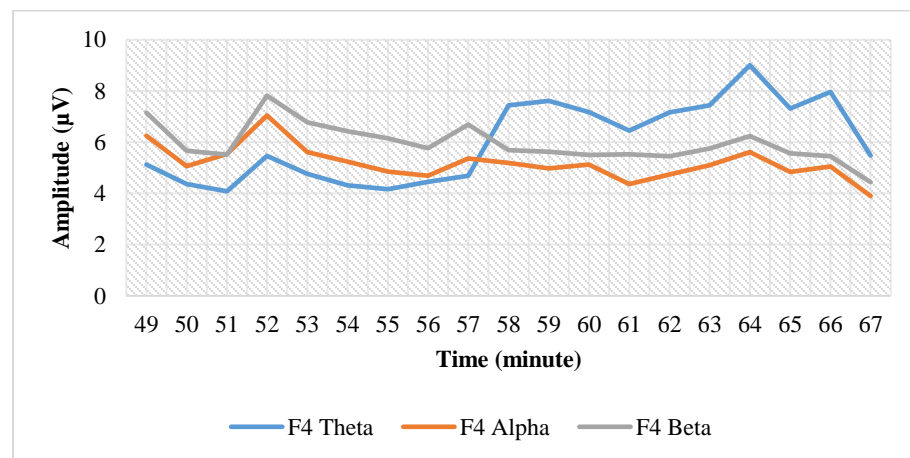

Figure 4.23 RMS Graphic on Respondent 4 at F4 by autodidact in the late morning

Figure 4.24 shows the amplitude RMS graphic of fourth respondent's EEG final signal on autodidact in the late morning at P3 channel. It shows that amplitude

of Beta was greater than Theta and Alpha until at the 57th minute, where the value of Beta, Theta, and Alpha was 7.5910, 5.3047, and 6.2330 µv at the 57th minute. Then, the amplitude of Theta (8.5144 µv) at the 58th minute increased and was greater than amplitude of Alpha (6.2105 µv) and Beta (7.0553 µv).

Figure 4.24 RMS Graphic on Respondent 4 at P3 by autodidact in the late morning

Figure 4.25 shows the amplitude RMS graphic of fourth respondent's EEG final signal on autodidact in the late morning at P4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 57th minute, where the value of Beta, Theta, and Alpha was 8.3547, 5.8612, and 6.7122 µv at the 57th minute. Then, the amplitude of Theta (8.5144 µv) at the 58th minute increased and was greater than amplitude of Alpha (6.2105 µv) and Beta (7.0553 µv).
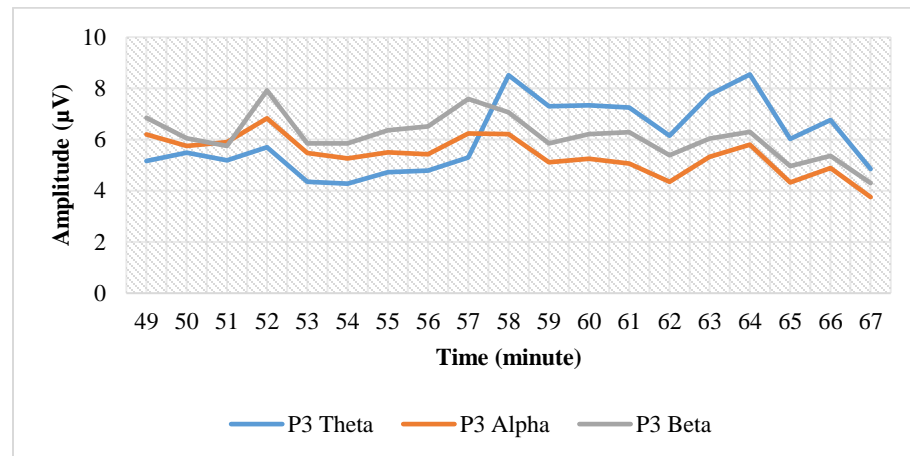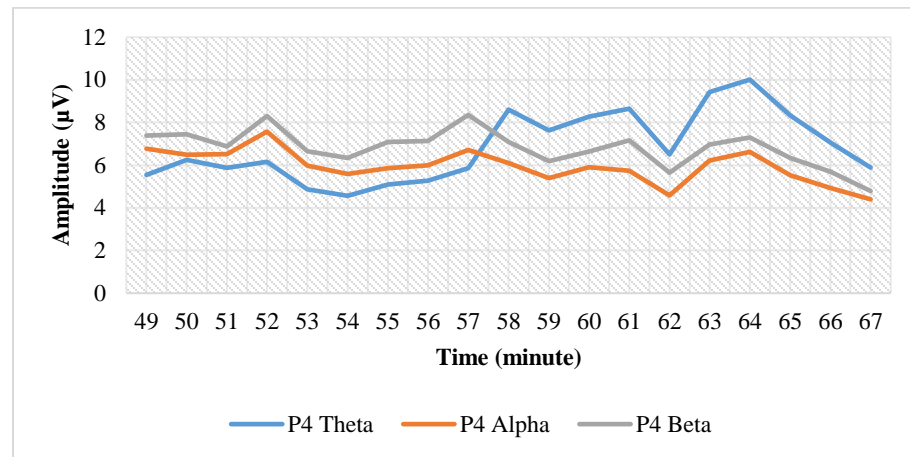
Figure 4.25 RMS Graphic on Respondent 4 at P4 by autodidact in the late morning

Based on Figure 4.22 and Figure 4.23, the ability of respondent 4 to memorize and solve problems appeared until at 57th minute. Then at 58th minute, it decreased and respondent 4 felt sleepy. As well as shown on Figure 4.24 and Figure 4.25, the ability of respondent 4 to read and understand the lesson appeared until at the 57th minute. Then at the 58th minute, it decreased and respondent 4 felt sleepy. It indicated that respondent 4 had not focussed on Physics subject at the 58th minute during studying on autodidact in the late morning.

4.2.2.2   Autodidact in the Afternoon

a.   Respondent 1

Figure 4.26 shows the amplitude RMS graphic of first respondent's EEG final signal on autodidact in the afternoon at F3 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 27th minute, where the value of Beta, Theta, and Alpha was 8.7847, 4.2864, and 6.7219 µv at the 27th minute. Then, the amplitude of Beta (2.3830 µv) at the 28th minute decreased and the amplitude of Theta (3.0313 µv) was the highest. After at the 28th minute, amplitude of Theta was fluctuated and reach the highest value (9.9867 µv) at the 34th minute.

Figure 4.26 RMS Graphic on Respondent 1 at F3 by autodidact in the afternoon

Figure 4.27 shows the amplitude RMS graphic of first respondent's EEG final signal on autodidact in the afternoon at F4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 29th minute, where the value of Beta, Theta, and Alpha was 3.6613, 3.0772, and 3.0198 µv at the 29th minute. Then, the amplitude of Theta (4.3081 µv) at the 30th minute increased and was greater than amplitude of Alpha (3.2684 µv) and Beta (3.2684 µv). After at the 30th minute, amplitude of Theta was fluctuated and reach the highest value (10.0617 µv) at the 34th minute. Meanwhile, after at the 36th minute, the amplitude of Alpha (5.7610 µv) was greater than amplitude of Theta (5.4538 µv) and Beta (4.6985 µv).
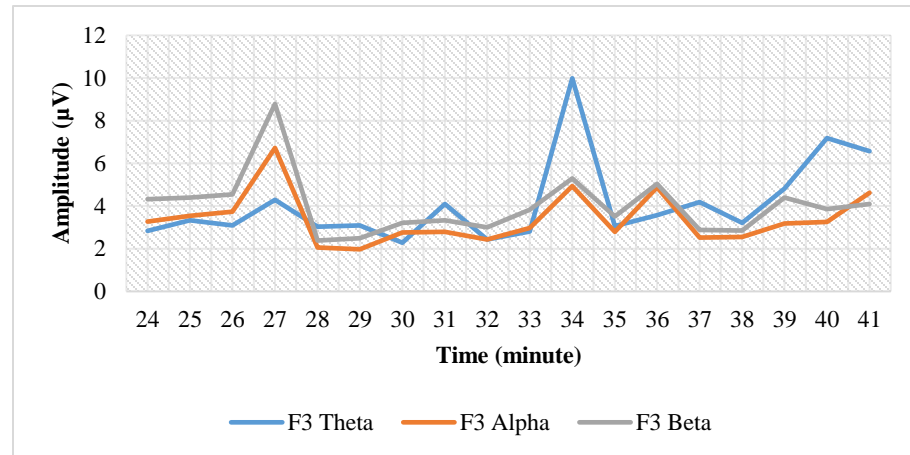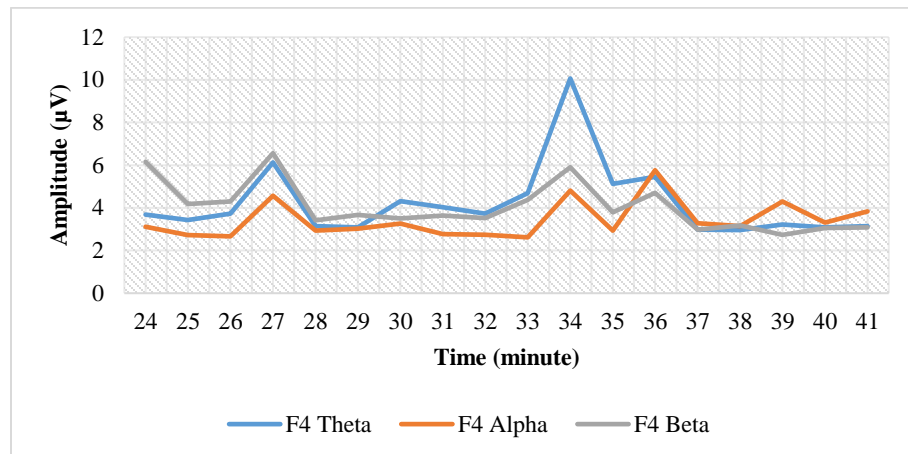
Figure 4.27 RMS Graphic on Respondent 1 at F4 by autodidact in the afternoon

Figure 4.28 shows the amplitude RMS graphic of first respondent's EEG final signal on autodidact in the afternoon at P3 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 28th minute, where the value of Beta, Theta, and Alpha was 3.6733, 3.4064, and 3.6389 µv at the 28th minute. Then, the amplitude of Theta (4.6204 µv) at 30th minute increased and was greater than amplitude of Alpha (4.2592 µv) and Beta (4.0673 µv). After at the 30th minute, amplitude of Theta was fluctuated and reach the highest value (10.0162 µv) at 34th minute. Meanwhile, after at the 37th minute, the amplitude of Alpha (4.7807 µv) was greater than amplitude of Theta (3.5030 µv) and Beta (4.3372 µv).
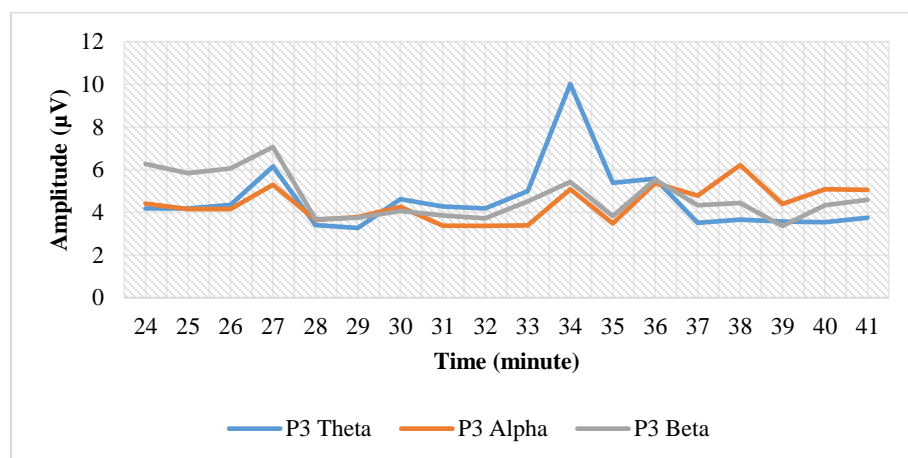

Figure 4.28 RMS Graphic on Respondent 1 at P3 by autodidact in the afternoon

Figure 4.29 shows the amplitude RMS graphic of first respondent's EEG final signal on autodidact in the afternoon at P4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 29th minute, where the value of Beta, Theta, and Alpha was 3.6287, 3.1757, and 3.3592 µv at the 29th minute. Then, the amplitude of Theta (4.9562 µv) at the 31st minute increased and was greater than amplitude of Alpha (3.3172 µv) and Beta (4.0678 µv). After at the 31st minute, amplitude of Theta was fluctuated and reach the highest value (9.8503 µv) at the 34th minute. Meanwhile, after at the 37th minute, the amplitude of Alpha (3.8849 µv) was greater than amplitude of Theta (2.9979 µv) and Beta (3.8801 µv).
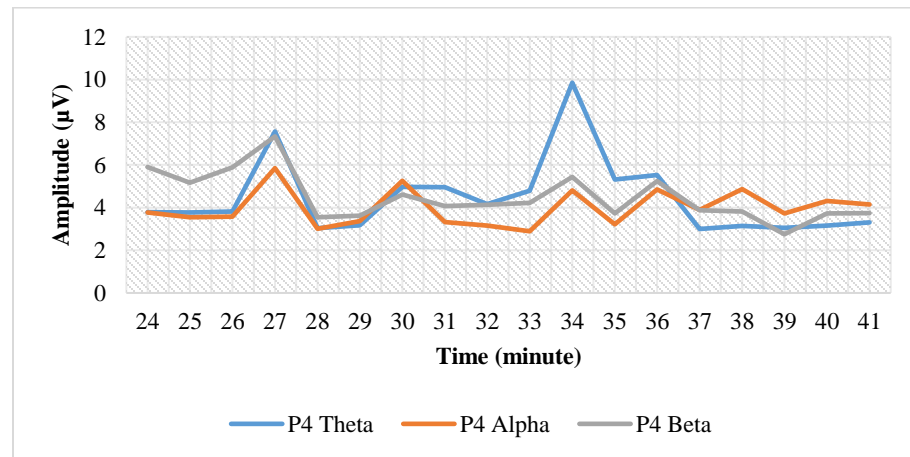
Figure 4.29 RMS Graphic on Respondent 1 at P4 by autodidact in the afternoon

Based on Figure 4.26 and Figure 4.27 the ability of respondent 1 to memorize and solve problems appeared until at the 33rd minute. Then at the 34th minute, it decreased and respondent 4 felt sleepy. As well as shown on Figure 4.28 and Figure 4.29, the ability of respondent 4 to read and understand the lesson appeared until at the 29th minute. Then at the 30th minute, it decreased and respondent 4 had no concentration and felt sleepy. It indicated that respondent 4 had not focussed on Physics subject at the 34th minute during studying on autodidact in the afternoon.

b.   Respondent 2

Figure 4.30 shows the amplitude RMS graphic of second respondent's EEG final signal on autodidact in the afternoon at F3 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 30th minute, where the value of Beta, Theta, and Alpha was 26.0160, 15.8900, and 19.0639 µv at the 30th minute. Then, the amplitude of Theta (27.9968 µv) at the 31st minute increased and was always the greatest compare to amplitude of Alpha (19.5315 µv) and Beta (16.3449 µv).

Figure 4.30 RMS Graphic on Respondent 2 at F3 by autodidact in the afternoon

Figure 4.31 shows the amplitude RMS graphic of second respondent's EEG final signal on autodidact in the afternoon at F4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 30th minute, where the value of Beta, Theta, and Alpha was 16.5166, 10.0217, and 11.4230 µv at the 30th minute. Then, the amplitude of Theta (22.8917 µv) at the 31st minute increased and was always the greatest compare to amplitude of Alpha (17.9839 µv) and Beta (14.1968 µv).

Figure 4.31 RMS Graphic on Respondent 2 at F4 by autodidact in the afternoon

Figure 4.32 shows the amplitude RMS graphic of second respondent's EEG final signal on autodidact in the afternoon at P3 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 30th minute, where the value of Beta, Theta, and Alpha was 17.5960, 11.4130, and 11.6926 µv at the 30th minute. Then, the amplitude of Theta (15.4722 µv) at the 31st minute increased and was always the greatest compare to amplitude of Alpha (12.1413 µv) and Beta (10.0723 µv).
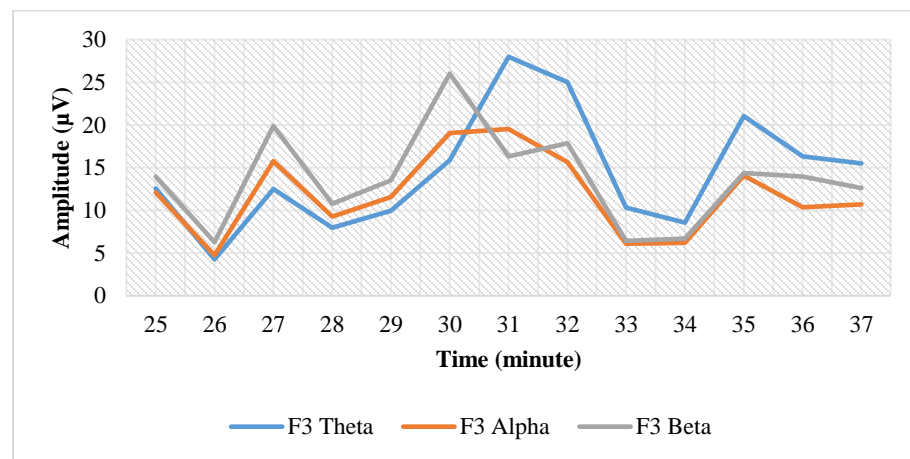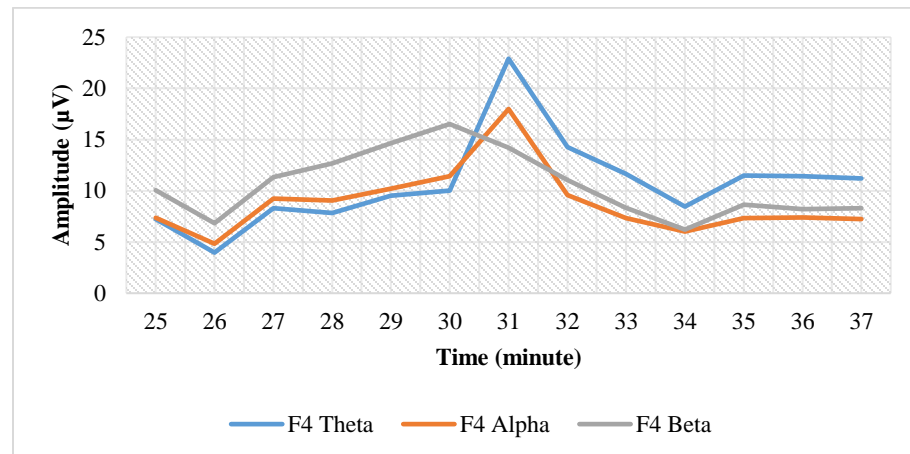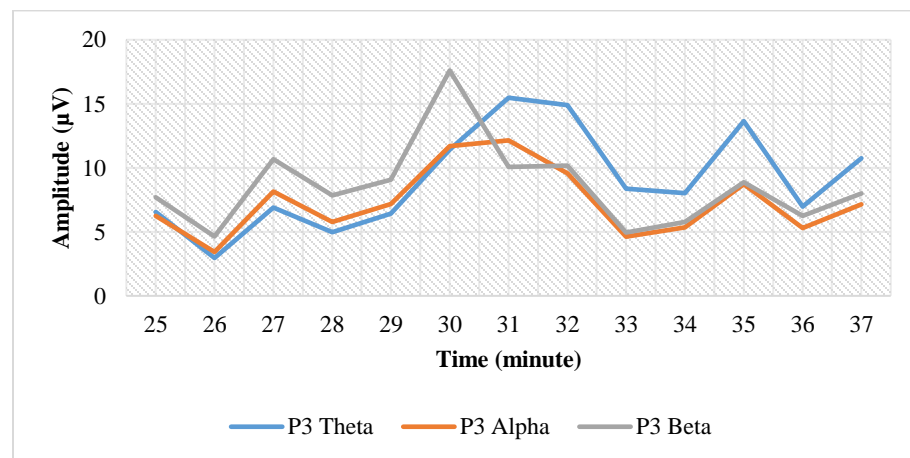

Figure 4.32 RMS Graphic on Respondent 2 at P3 by autodidact in the afternoon

Figure 4.33 shows the amplitude RMS graphic of second respondent's EEG final signal on autodidact in the afternoon at P4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 30th minute, where the value

of Beta, Theta, and Alpha was 15.0935, 9.6349, and 10,5910 µv at the 30th minute. Then, the amplitude of Theta (14.4857 µv) at the 31st minute increased and was always the greatest compare to amplitude of Alpha (10.2969 µv) and Beta (9.0022 µv).
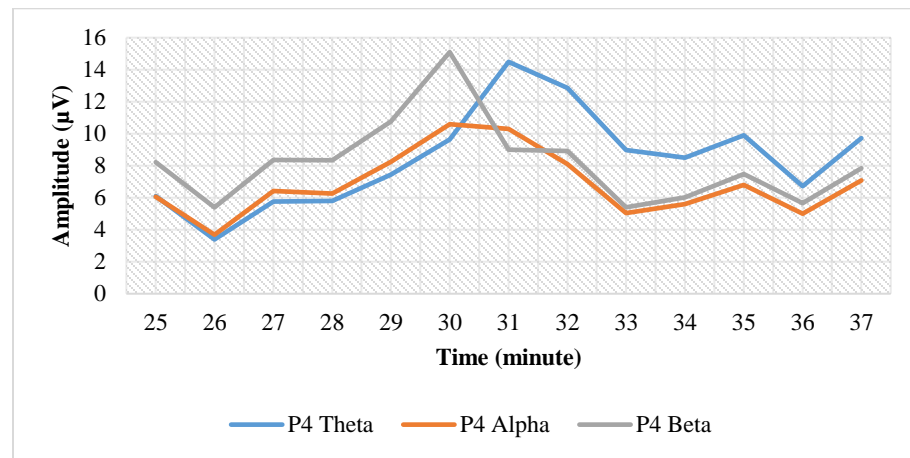

Figure 4.33 RMS Graphic on Respondent 2 at P4 by autodidact in the afternoon

Based on Figure 4.30 and Figure 4.31, the ability of respondent 2 to memorize and solve problems appeared until at the 30th minute. Then at the 31st minute, it decreased and respondent 2 felt sleepy. As well as shown on Figure 4.32 and Figure 4.33, the ability of respondent 2 to read and understand the lesson appeared until at the 30th minute. Then at the 31st minute, it decreased and respondent 4 felt sleepy. It indicated that respondent 2 had not focussed on Physics subject at the 31st minute during studying on autodidact in the afternoon.

c.   Respondent 3

Figure 4.34 shows the amplitude RMS graphic of third respondent's EEG final signal on autodidact in the afternoon at F3 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 26th minute, where the value of Beta, Theta, and Alpha was 20.4273, 13.6089, and 19.5308 µv at the 26th minute. Then, the amplitude of Theta (17.6676 µv) at the 27th minute increased and was always the greatest compare to amplitude of Alpha (11.2063 µv) and Beta (11.7180 µv).

Figure 4.34 RMS Graphic on Respondent 3 at F3 by autodidact in the afternoon

Figure 4.35 shows the amplitude RMS graphic of third respondent's EEG final signal on autodidact in the afternoon at F4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 26th minute, where the value of Beta, Theta, and Alpha was 11.2745, 6.2200, and 8.7506 µv at the 26th minute. Then, the amplitude of Theta (10.4236 µv) at the 27th minute increased and was always the greatest compare to amplitude of Alpha (6.7660 µv) and Beta (7.3857 µv).

Figure 4.35 RMS Graphic on Respondent 3 at F4 by autodidact in the afternoon

Figure 4.36 shows the amplitude RMS graphic of third respondent's EEG final signal on autodidact in the afternoon at P3 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 26th minute, where the value

of Beta, Theta, and Alpha was 10.2215, 6.3931, and 7.6586 µv at the 26th minute. Then, the amplitude of Theta (11.0999 µv) at the 27th minute increased and was always the greatest compare to amplitude of Alpha (6.8303 µv) and Beta (7.6883µv).
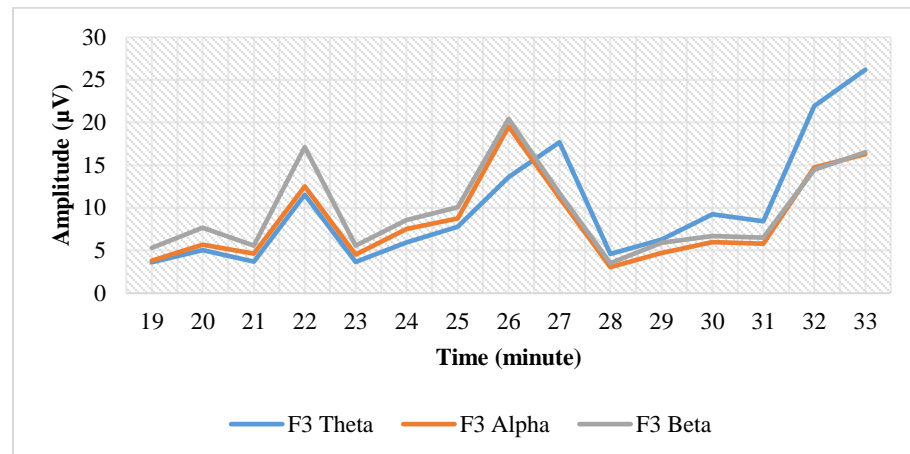

Figure 4.36 RMS Graphic on Respondent 3 at P3 by autodidact in the afternoon

Figure 4.37 shows the amplitude RMS graphic of third respondent's EEG final signal on autodidact in the afternoon at P4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 26th minute, where the value of Beta, Theta, and Alpha was 8.5976, 5.9093, and 7.0809 µv at the 26th minute. Then, the amplitude of Theta (12.6634 µv) at the 27th minute increased and was always the greatest compare to amplitude of Alpha (7.4625µv) and Beta (8.2407 µv).

Figure 4.37 RMS Graphic on Respondent 3 at P4 by autodidact in the afternoon

Based on Figure 4.34 and Figure 4.35, the ability of respondent 3 to memorize and solve problems appeared until at the 26th minute. Then at the 27th minute, it decreased and respondent 3 felt sleepy. As well as shown on Figure 4.36 and Figure 4.37, the ability of respondent 3 to read and understand the lesson appeared until at the 26th minute. Then at the 27th minute, it decreased and respondent 3 felt sleepy. It indicated that respondent 3 had not focussed on Physics subject at the 27th minute during studying on autodidact in the afternoon.

d.   Respondent 4

Figure 4.38 shows the amplitude RMS graphic of fourth respondent's EEG final signal on autodidact in the afternoon at F3 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 19th minute, where the value of Beta, Theta, and Alpha was 10.5801, 10.5690, and 7.4175 µv at the 19th minute. Then, the amplitude of Theta (19.2665 µv) at 20th minute increased and was the greatest compare to amplitude of Alpha (13.8420 µv) and Beta (17.7845 µv). At the 21st to 24th minute. The amplitude of Beta at the 21st to 24th minute increased again, yet decreased at the 25th minute. The amplitude of Theta (10.5793 µv) at the 25th minutes increased and was the greatest compare to amplitude of Alpha (6.3850 µv) and Beta (8.7903 µv).
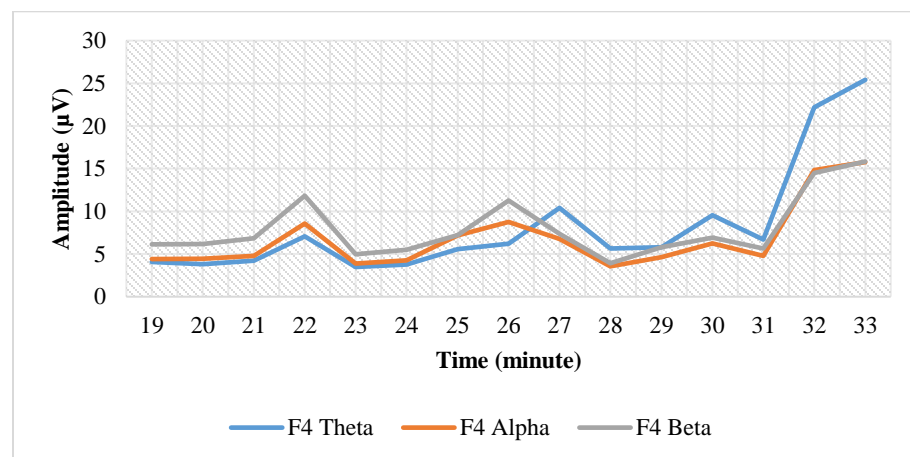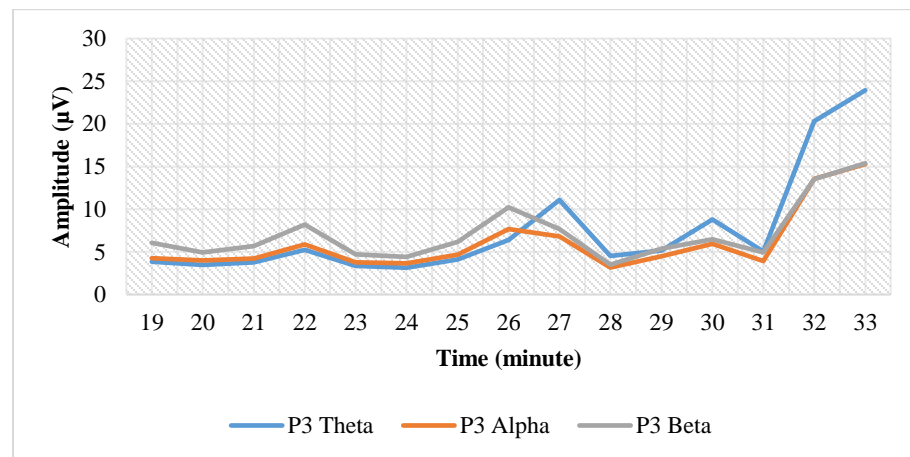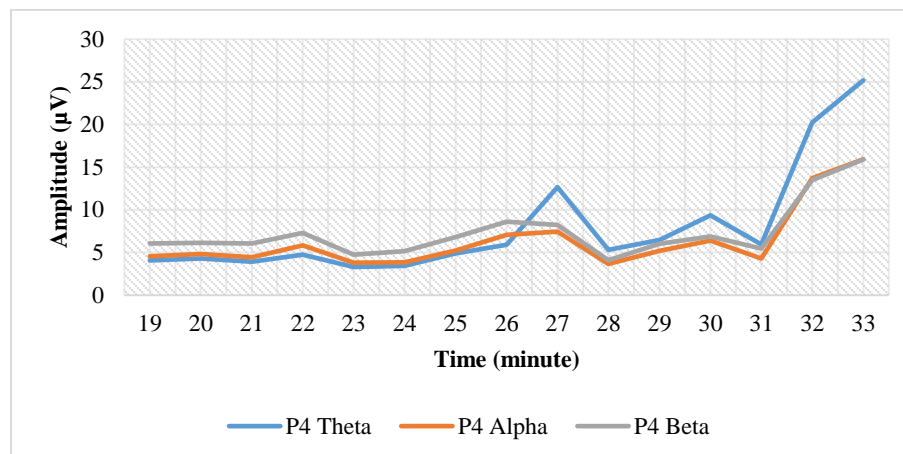
Figure 4.38 RMS Graphic on Respondent 4 at F3 by autodidact in the afternoon

Figure 4.39 shows the amplitude RMS graphic of fourth respondent's EEG final signal on autodidact in the afternoon at F4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 24th minute, where the value of Beta, Theta, and Alpha was 12.1313, 5.9231, and 6.6621 µv at the 24th minute. Then, the amplitude of Theta (13.1314 µv) at the 25th minute increased and was always the greatest compare to amplitude of Alpha (6.5406 µv) and Beta (6.9262 µv).

Figure 4.39 RMS Graphic on Respondent 4 at F4 by autodidact in the afternoon

Figure 4.40 shows the amplitude RMS graphic of fourth respondent's EEG final signal on autodidact in the afternoon at P3 channel. It shows that amplitude

of Beta was greater than Theta and Alpha until at the 24th minute, where the value of Beta, Theta, and Alpha was 10.9936, 6.1053, and 6.0158 µv at the 24th minute. Then, the amplitude of Theta (9.9660 µv) at the 25th minute increased and was always the greatest compare to amplitude of Alpha (4.8883 µv) and Beta (5.4153 µv).
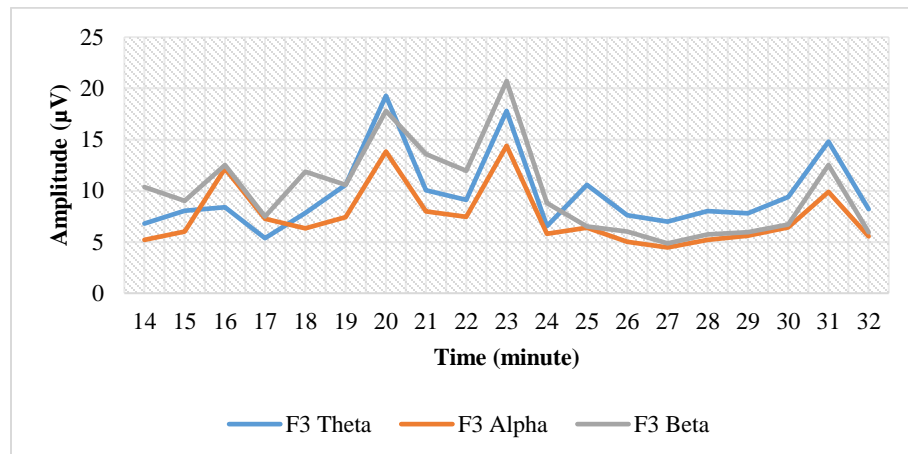

Figure 4.40 RMS Graphic on Respondent 4 at P3 by autodidact in the afternoon

Figure 4.41 shows the amplitude RMS graphic of fourth respondent's EEG final signal on autodidact in the afternoon at P4 channel. It shows that amplitude of Beta was greater than Theta and Alpha until at the 24th minute, where the value of Beta, Theta, and Alpha was 12.1618, 6.6384, 7.1435 µv at the 24th minute. Then, the amplitude of Theta (11.6662 µv) at the 25th minute increased and was always the greatest compare to amplitude of Alpha (5.9402 µv) and Beta (6.4821 µv).
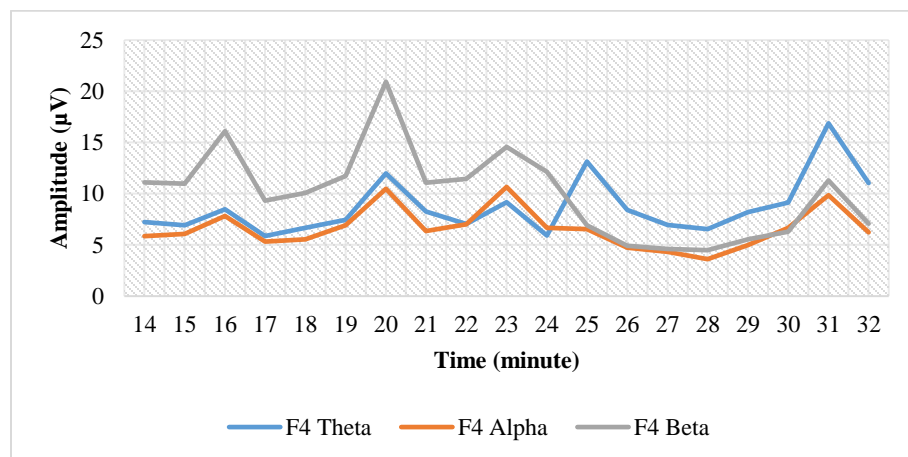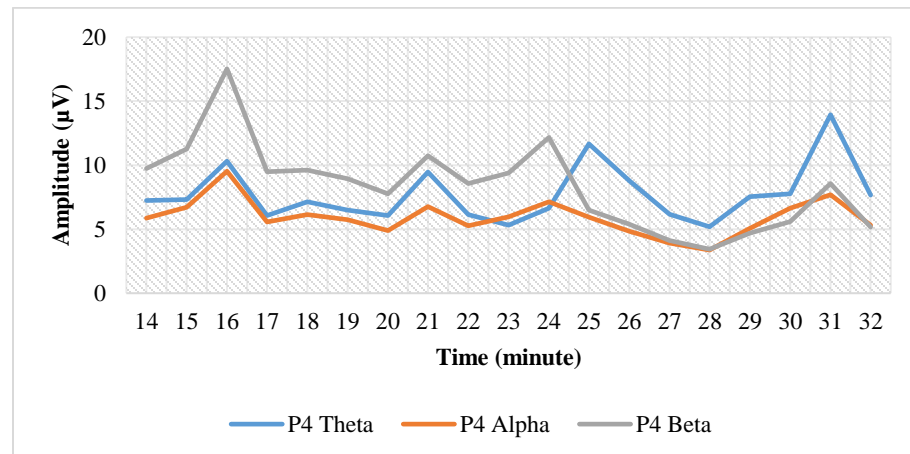
Figure 4.41 RMS Graphic on Respondent 4 at P4 by autodidact in the afternoon

Based on Figure 4.38 and Figure 4.39, the ability of respondent 4 to memorize and solve problems appeared until at the 24th minute. Then at the 25th minute, it decreased and respondent 4 felt sleepy. As well as shown on Figure 4.40 and Figure 4.41, the ability of respondent 4 to read and understand the lesson appeared until at the 24th minute. Then at the 25th minute, it decreased and respondent 4 felt sleepy. It indicated that respondent 4 had not focussed on Physics subject at the 25th minute during studying on autodidact in the afternoon.

4.2.2.3   Non-Autodidact in the Late Morning

a.   Respondent 1

Figure 4.42 shows the amplitude RMS graphic of first respondent's EEG final signal on non-autodidact in the late morning at F3 channel. It shows that amplitude of Beta was always the greatest compare to Theta and Alpha until at the 81st minute, where the amplitude of Beta at the 80th minutes started to decrease. The value of Beta, Theta, and Alpha amplitude was 3.7257, 2.2428, and 1.9094 µv at the 81st minute. Then, the amplitude of Alpha and Theta fluctuated at 82nd minute. Amplitude alpha at the 82nd (3.3984 µv) was the greatest compare to amplitude of Theta (2.0918 µv) and Beta (3.3555 µv). Furthermore, the amplitude of Theta was

the greatest at the 85th minute (5.7553 µv) and at the 88th minute (5.6805 µv) compare to amplitude of Alpha and Beta.
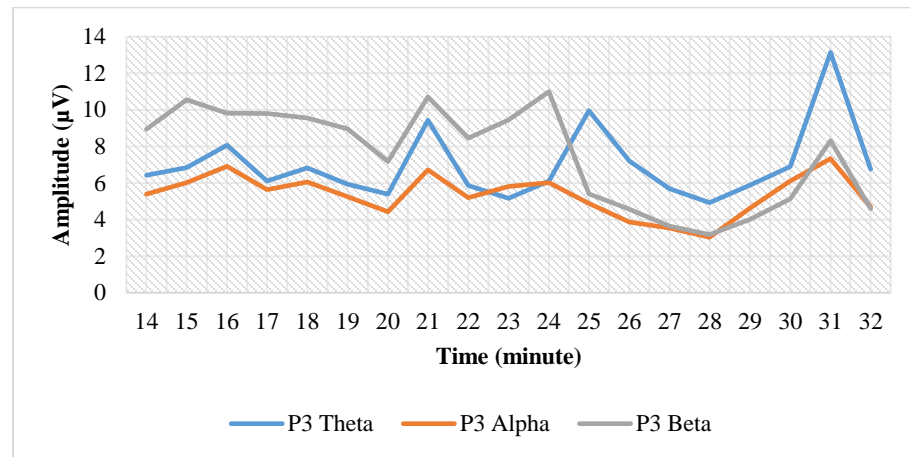

Figure 4.42 RMS Graphic on Respondent 1 at F3 by non-autodidact in the late morning

Figure 4.43 shows the amplitude RMS graphic of first respondent's EEG final signal on non-autodidact in the late morning at F4 channel. It shows that amplitude of Beta was always the greatest compare to Theta and Alpha until at the 79th minute, where the value of Beta, Theta, and Alpha amplitude was 4.3562, 2.5588, and 2.7716 µv at the 79th minute. Then, the amplitude of Alpha and Theta started fluctuating at the 80th minute. Amplitude alpha at the 80th minute (3.3984 µv), at the 82nd minute (3.6710 µv), and at the 86th minute (3.2769) was the greatest compare to amplitude of Theta and Beta. Furthermore, the amplitude of Theta was the greatest at the 85th minute (5.5458 µv) and at the 88th minute (5.4593 µv) compare to amplitude of Alpha and Beta.

Figure 4.43 RMS Graphic on Respondent 1 at F4 by non-autodidact in the late morning

Figure 4.44 shows the amplitude RMS graphic of first respondent's EEG final signal on non-autodidact in the late morning at P3 channel. It shows that amplitude of Beta was always the greatest compare to Theta and Alpha until at the 79th minute, where the value of Beta, Theta, and Alpha amplitude was 4.7226, 2.1892, 3.5149 µv at the 79th minute. Then, the amplitude of Alpha and Theta started fluctuating at the 80th minute. Amplitude alpha at the 80th minute (3.5149 µv), at the 82nd minute (4.8199 µv), at the 86th minute (4.2909 µv), and at the 89th minute (4.4182 µv) was the greatest compare to amplitude of Theta and Beta. Furthermore, the amplitude of Theta was the greatest at the 85th minute (3.7587 µv) and at the 88th minute (3.7251µv) compare to amplitude of Alpha and Beta.
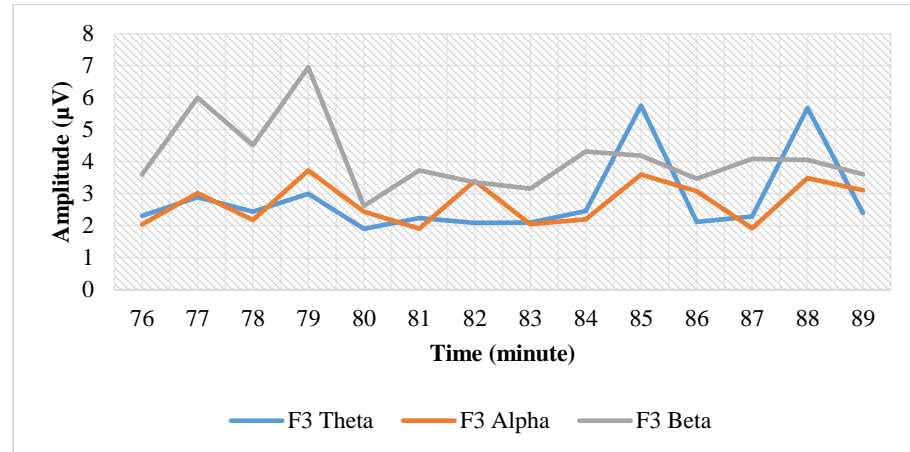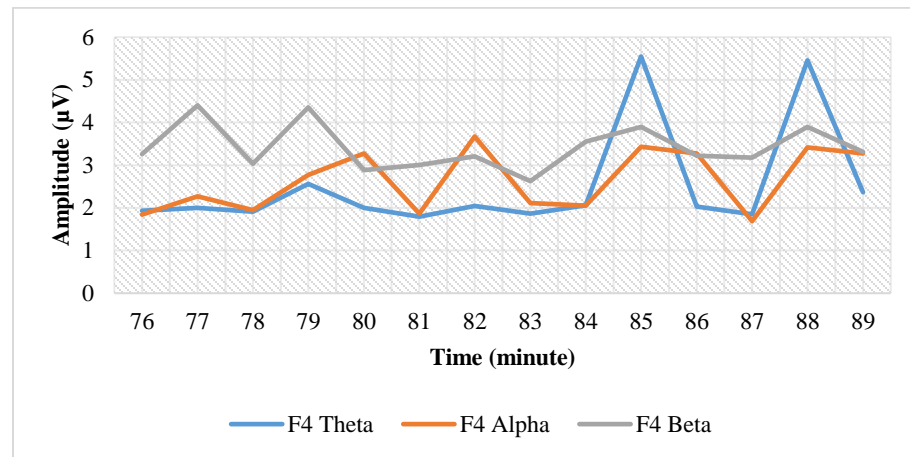
Figure 4.44 RMS Graphic on Respondent 1 at P3 by non-autodidact in the late morning

Figure 4.45 shows the amplitude RMS graphic of first respondent's EEG final signal on non-autodidact in the late morning at P4 channel. It shows that amplitude of Beta was always the greatest compare to Theta and Alpha until at the 79th minute, where the value of Beta, Theta, and Alpha amplitude was 3.9214, 1.9024, and 3.1048 µv at the 79th minute. Then, the amplitude of Alpha and Theta started fluctuating at the 80th minute. Amplitude alpha at the 80th minute (3.1048 µv), at the 82nd minute (4.2237 µv), at the 86th minute (3.8063 µv), and at the 89th minute (3.8456 µv) was the greatest compare to amplitude of Theta and Beta. Furthermore, the amplitude of Theta was the greatest at the 85th minute (5.6060 µv) and at the 88th minute (3.4638 µv) compare to amplitude of Alpha and Beta.

Figure 4.45 RMS Graphic on Respondent 1 at P4 by non-autodidact in the late morning

Based on Figure 4.42 and Figure 4.43, the ability of respondent 1 to memorize and solve problems appeared until at the 81st minute. Then at the 82nd minute, it decreased and respondent 1 had no concentration then felt sleepy at the 85th minute. As well as shown on Figure 4.44 and Figure 4.45, the ability of respondent 1 to read and understand the lesson appeared until at the 79th minute. Then at the 80th minute, it decreased and respondent 1 had no concentration then felt sleepy. It indicated that respondent 1 had not focussed on Physics subject at the 82nd minute during studying on non-autodidact in the late morning.

b.   Respondent 2

Figure 4.46 shows the amplitude RMS graphic of second respondent's EEG final signal on non-autodidact in the late morning at F3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 56th minute, where the value of Beta, Theta, and Alpha amplitude was 3.2371, 1.6989, and 1.8696 µv at the 56th minute. Then, the amplitude of Alpha and Theta started fluctuating at the 57th minute, while the amplitude of Beta was the lowest. Amplitude of Theta at the 57th minute (6.8598 µv) started increasing and was the greatest compare to amplitude of Alpha (4.1762 µv) and Beta (3.7114 µv).
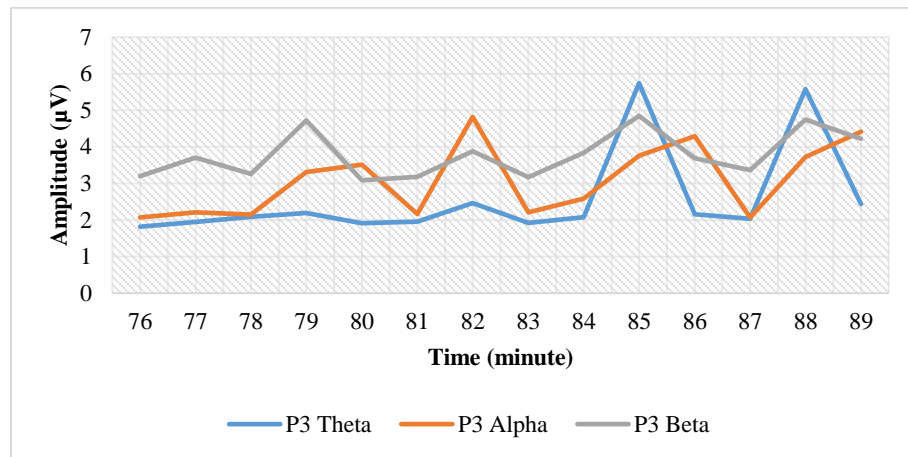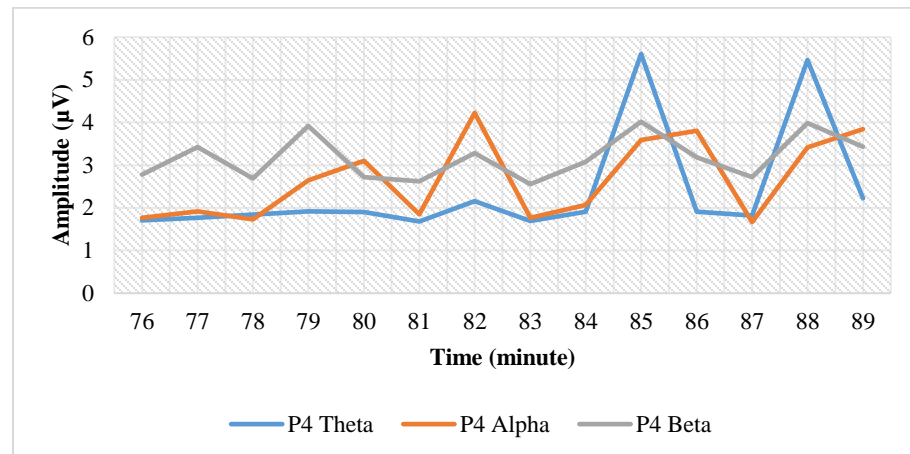
Figure 4.46 RMS Graphic on Respondent 2 at F3 by non-autodidact in the late morning

Figure 4.47 shows the amplitude RMS graphic of second respondent's EEG final signal on non-autodidact in the late morning at F4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 56th minute, where the value of Beta, Theta, and Alpha amplitude was 2.4175, 2.1551, and 1.6760 µv at the 56th minute. Then, the amplitude of Alpha and Theta started fluctuating at the 57th minute, while the amplitude of Beta was the lowest. Amplitude of Theta at the 57th minute (7.6446 µv) started increasing and was the greatest compare to amplitude of Alpha (4.6061 µv) and Beta (5.2286 µv).

Figure 4.47 RMS Graphic on Respondent 2 at F4 by non-autodidact in the late morning

Figure 4.48 shows the amplitude RMS graphic of second respondent's EEG final signal on non-autodidact in the late morning at P3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 56th minute, where the value of Beta, Theta, and Alpha amplitude was 3.3089, 2.3668, and 1.8540 µv at the 56th minute. Then, the amplitude of Alpha and Theta started fluctuating at the 57th minute, while the amplitude of Beta was the lowest. Amplitude of Theta at the 57th minute (6.9842 µv) started increasing and was the greatest compare to amplitude of Alpha (4.1828 µv) and Beta (4.3239 µv).
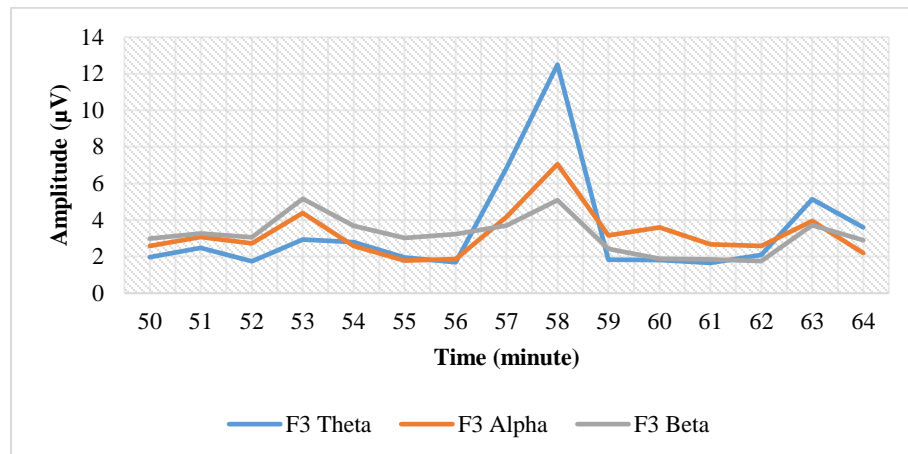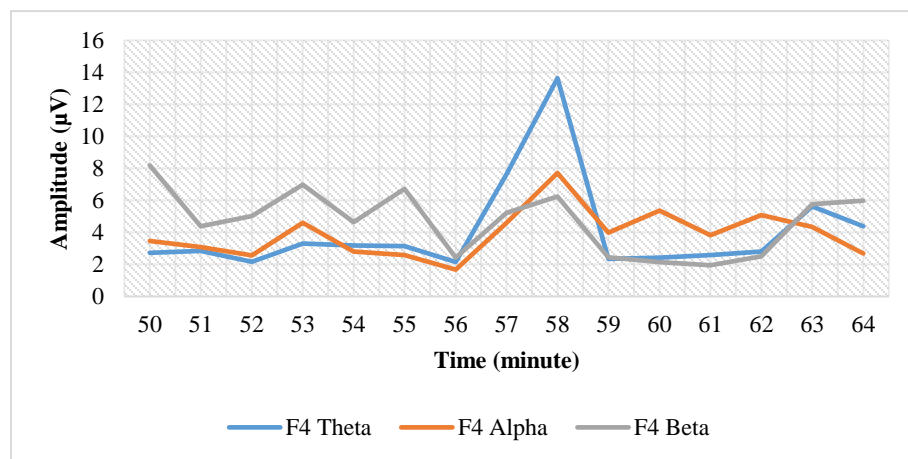

Figure 4.48 RMS Graphic on Respondent 2 at P3 by non-autodidact in the late morning

Figure 4.49 shows the amplitude RMS graphic of second respondent's EEG final signal on non-autodidact in the late morning at P4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 56th minute, where the value of Beta, Theta, and Alpha amplitude was 2.4997, 1.5873, and 1.6375 µv at the 56th minute. Then, the amplitude of Alpha and Theta started fluctuating at 57th minute, while the amplitude of Beta was the lowest. Amplitude of Theta at the 57th minute (7.0204 µv) started increasing and was the greatest compare to amplitude of Alpha (4.1804 µv) and Beta (3.5246 µv).
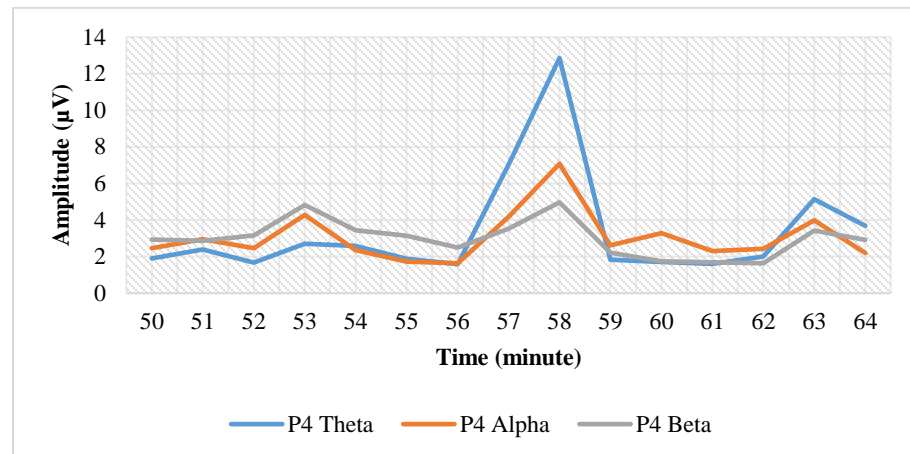
Figure 4.49 RMS Graphic on Respondent 2 at P4 by non-autodidact in the late morning

Based on Figure 4.46 and Figure 4.47, the ability of respondent 2 to memorize and solve problems appeared until at the 56th minute. Then at the 57th minute, it decreased and respondent 2 had no concentration and felt sleepy. As well as shown on Figure 4.48 and Figure 4.49, the ability of respondent 2 to read and understand the lesson appeared until at the 56th minute. Then at the 57th minute, it decreased and respondent 2 had no concentration and felt sleepy. It indicated that respondent 2 had not focussed on Physics subject at the 57th minute during studying on non-autodidact in the late morning.

c. Respondent 3

Figure 4.50 shows the amplitude RMS graphic of third respondent's EEG final signal on non-autodidact in the late morning at F3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 65th minute, where the value of Beta, Theta, and Alpha amplitude was 5.8887, 3.5721, and 3.2775 µv at the 65th minute. Then, the amplitude of Alpha and Theta started fluctuating at the 66th minute, while the amplitude of Beta was the lowest. Amplitude of Alpha at the 66th minute (4.5921 µv) started increasing and was the greatest compare to amplitude of Theta (3.1837 µv) and Beta (3.0305 µv).
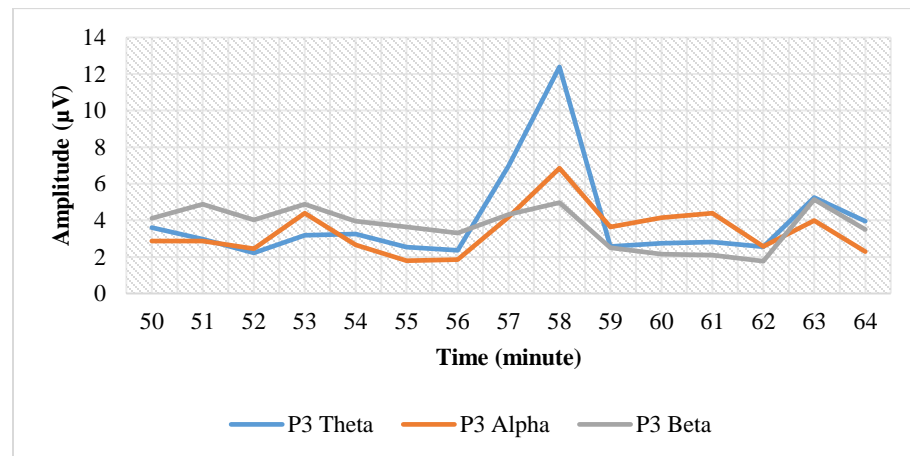
Figure 4.50 RMS Graphic on Respondent 3 at F3 by non-autodidact in the late morning

Figure 4.51 shows the amplitude RMS graphic of third respondent's EEG final signal on non-autodidact in the late morning at F4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 65th minute, where the value of Beta, Theta, and Alpha amplitude was 4.4997, 2.5615, and 3.1929 µv at the 65th minute. Then, the amplitude of Alpha and Theta started fluctuating at the 66th minute, while the amplitude of Beta was the lowest. Amplitude of Alpha at 66th minute (3.7154 µv) started increasing and was the greatest compare to amplitude of Theta (2.5905 µv) and Beta (3.3933 µv).

Figure 4.51 RMS Graphic on Respondent 3 at F4 by non-autodidact in the late morning

Figure 4.52 shows the amplitude RMS graphic of third respondent's EEG final signal on non-autodidact in the late morning at P3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 61st minute, where the value of Beta, Theta, and Alpha amplitude was 3.9008, 1.8860, and 2.8914 µv at the 61st minute. Then, the amplitude of Alpha and Beta started fluctuating at the 62nd minute. Alpha was the greatest among others at the 62nd to 64th, 66th, 70th, and 72nd minute. Meanwhile, Beta was the greatest among others at the 65th, 67th to 69th, and 71st minute.
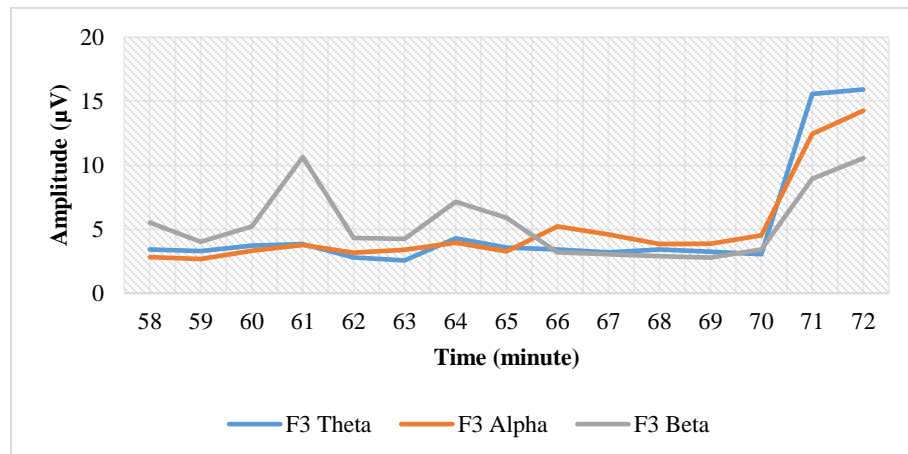

Figure 4.52 RMS Graphic on Respondent 3 at P3 by non-autodidact in the late morning

Figure 4.53 shows the amplitude RMS graphic of third respondent's EEG final signal on non-autodidact in the late morning at P4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 59th minute, where the value of Beta, Theta, and Alpha amplitude was 3.3634, 1.7405, and 3.2064 µv at the 59th minute. Then, the amplitude of Alpha and Beta started fluctuating at the 60th minute while the amplitude of Alpha was predominant higher than the amplitude of Beta.
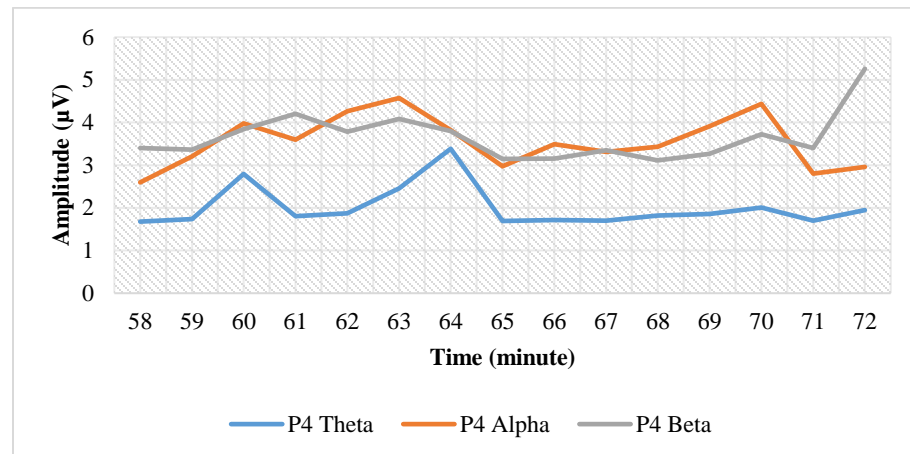
Figure 4.53 RMS Graphic on Respondent 3 at P4 by non-autodidact in the late morning

Based on Figure 4.50 and Figure 4.51, the ability of respondent 3 to memorize and solve problems appeared until at the 65th minute. Then at the 66th minute, it decreased and respondent 3 had no concentration. As well as shown on Figure 4.52 and Figure 4.53, the ability of respondent 3 to read and understand the lesson appeared until at the 61st minute. Then at the 62nd minute, it decreased and respondent 3 had no concentration. It indicated that respondent 3 had not focussed on Physics subject at the 66th minute during studying on non-autodidact in the late morning.

d.   Respondent 4

Figure 4.54 shows the amplitude RMS graphic of fourth respondent's EEG final signal on non-autodidact in the late morning at F3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 56th minute, where the value of Beta, Theta, and Alpha amplitude was 5.0257, 4.4861, and 4.2268 µv at the 56th minute. Then, the amplitude of Theta and Alpha increased at the 57th minute where Theta and Alpha was predominant higher than Beta after the 57th minute. The value of Theta, Alpha, and Beta amplitude at the 57th minute was 5.5577, 5.0168, and 5.4678 µv.
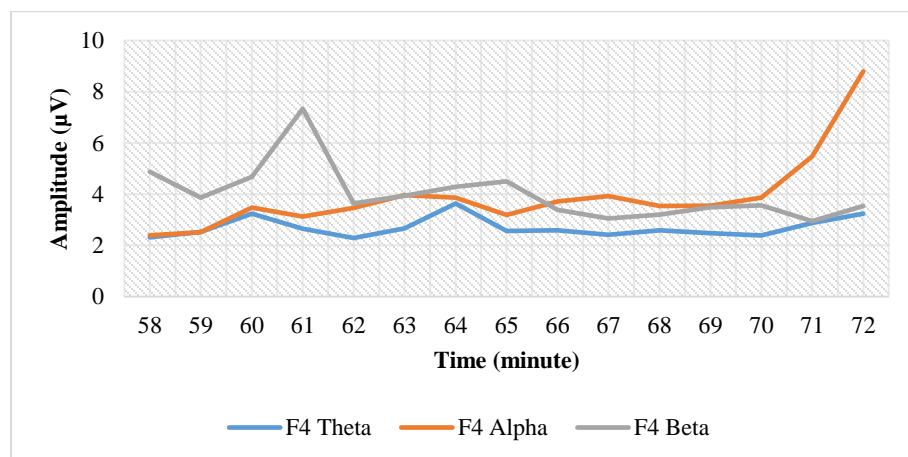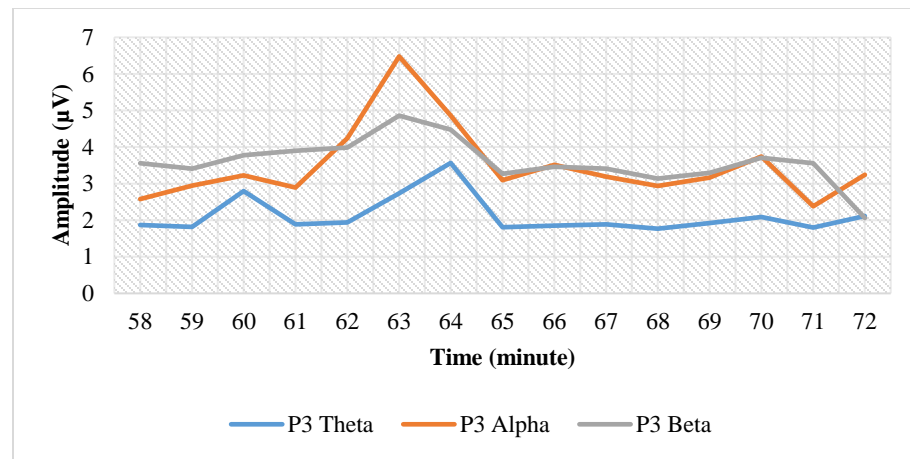
Figure 4.54 RMS Graphic on Respondent 4 at F3 by non-autodidact in the late morning

Figure 4.55 shows the amplitude RMS graphic of fourth respondent's EEG final signal on non-autodidact in the late morning at F4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 57th minute, where the value of Beta, Theta, and Alpha amplitude was 6.3680, 5.1899, and 4.7779 µv at the 57th minute. Then, the amplitude of Theta and Alpha increased at the 58th minute where Theta and Alpha was predominant higher than Beta after the 62nd minute. The value of Theta, Alpha, and Beta amplitude at the 58th minute was 8.9971, 7.3735, and 6.2915 µv.
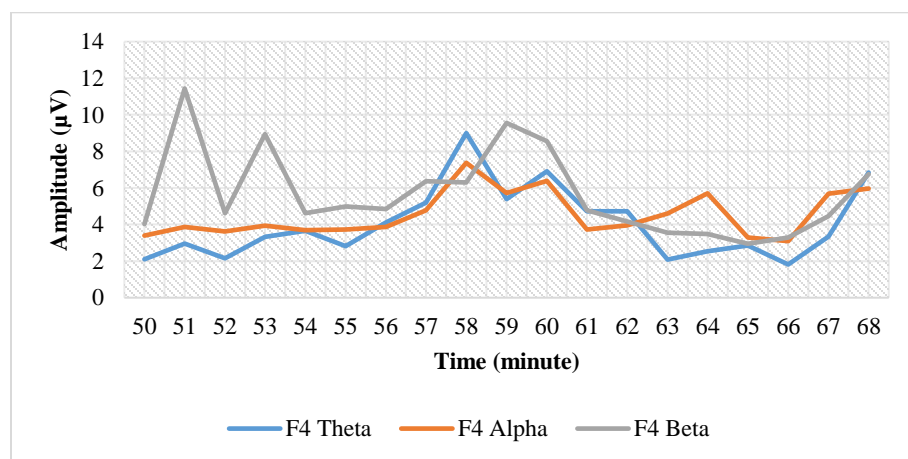
Figure 4.55 RMS Graphic on Respondent 4 at F4 by non-autodidact in the late morning

Figure 4.56 shows the amplitude RMS graphic of fourth respondent's EEG final signal on non-autodidact in the late morning at P3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 57th minute, where the value of Beta, Theta, and Alpha amplitude was 5.4876, 5.3140, 4.8419 µv at the 57th minute. Then, the amplitude of Theta and Alpha increased at the 58th minute where Theta and Alpha was predominant higher than Beta after the 61st minute. The value of Theta, Alpha, and Beta amplitude at the 58th minute was 9.3799, 7.4611, and 6.6303 µv.
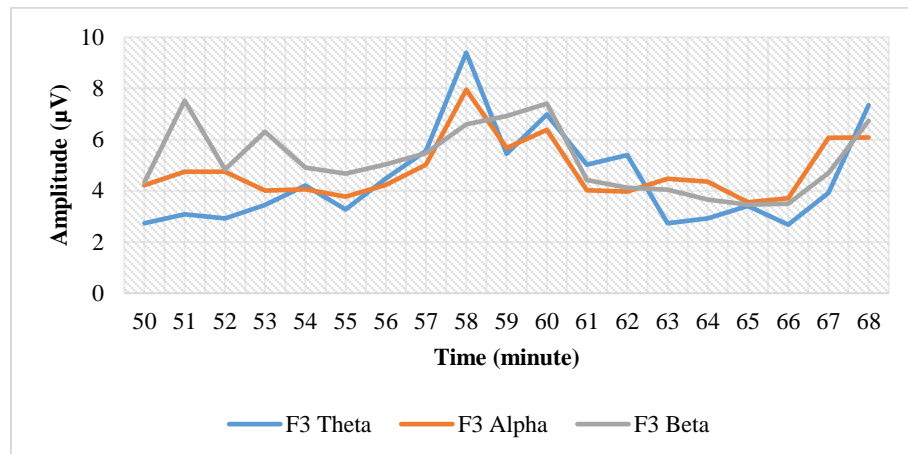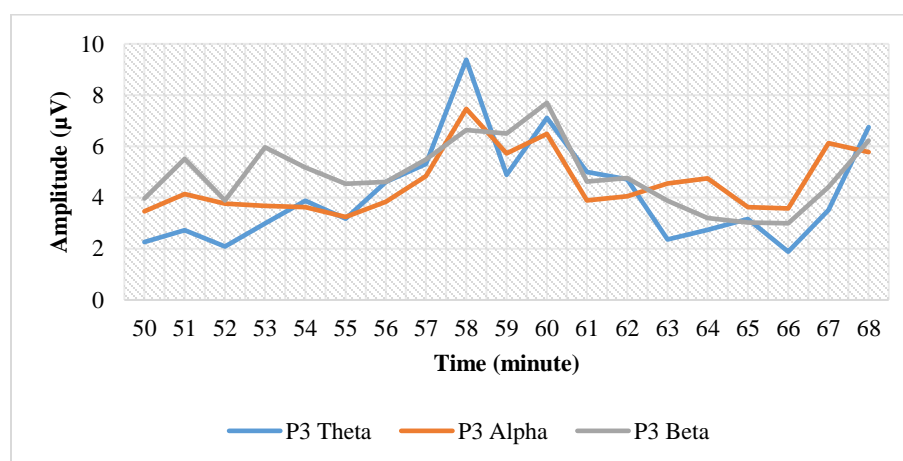

Figure 4.56 RMS Graphic on Respondent 4 at P3 by non-autodidact in the late morning

Figure 4.57 shows the amplitude RMS graphic of fourth respondent's EEG final signal on non-autodidact in the late morning at P4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 57th minute, where the value of Beta, Theta, and Alpha amplitude was 5.0671, 4.8549, and 4.8678 µv at the 57th minute. Then, the amplitude of Theta and Alpha increased at the 58th minute where Theta and Alpha was predominant higher than Beta after the 61st minute. The value of Theta, Alpha, and Beta amplitude at the 58th minute was 8.6575, 7.4332, and 6.4409 µv.
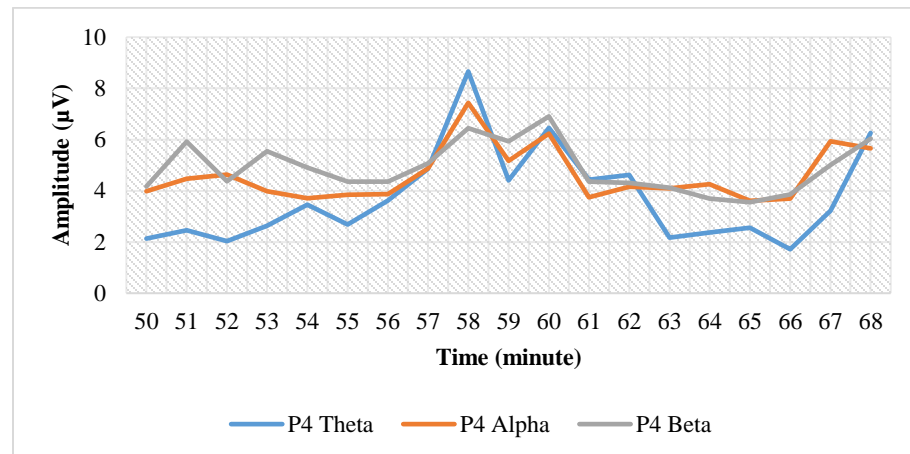
Figure 4.57 RMS Graphic on Respondent 4 at P4 by non-autodidact in the late morning

Based on Figure 4.54 and Figure 4.55, the ability of respondent 4 to memorize and solve problems appeared until at the 56th minute. Then at the 57th minute, it decreased and respondent 4 felt sleepy and had no concentration. As well as shown on Figure 4.56 and Figure 4.57, the ability of respondent 4 to read and understand the lesson appeared until at the 57th minute. Then at the 58th minute, it decreased and respondent 4 felt sleepy and had no concentration. It indicated that respondent 4 had not focussed on Physics subject at the 57th minute during studying on non-autodidact in the late morning.

4.2.2.4   Non-Autodidact in the Afternoon

a.   Respondent 1

Figure 4.58 shows the amplitude RMS graphic of first respondent's EEG final signal on non-autodidact in the afternoon at F3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 19th minute, where the value of Beta, Theta, and Alpha amplitude was 3.2666, 2.3876, and 2.0760 µv at the 19th minute. Then, the amplitude of Theta and Alpha increased at the 20th minute whereas the amplitude of Beta was the lowest among others. The value of

Theta, Alpha, and Beta amplitude at the 20th minute was 3.5549, 2.5376, and 3.2191 µv.

Figure 4.58 RMS Graphic on Respondent 1 at F3 by non-autodidact in the afternoon

Figure 4.59 shows the amplitude RMS graphic of first respondent's EEG final signal on non-autodidact in the afternoon at F4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 20th minute, where the value of Beta, Theta, and Alpha amplitude was 2.9661, 2.7277, and 2.3760 µv at the 20th minute. Then, the amplitude of Theta and Alpha increased at the 21st minute whereas the amplitude of Beta was the lowest among others. The value of Theta, Alpha, and Beta amplitude at the 21st minute was 3.5784, 3.1291, and 3.2746 µv.

Figure 4.59 RMS Graphic on Respondent 1 at F4 by non-autodidact in the afternoon

Figure 4.60 shows the amplitude RMS graphic of first respondent's EEG final signal on non-autodidact in the afternoon at P3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 19th minute, where the value of Beta, Theta, and Alpha amplitude was 3.0003, 2.2568, and 2.0444 µv at the 19th minute. Then, the amplitude of Theta increased at the 20th minute whereas the amplitude of Beta was the lowest among others. The value of Theta, Alpha, and Beta amplitude at the 20th minute was 2.9737, 2.3341, and 2.8317 µv.
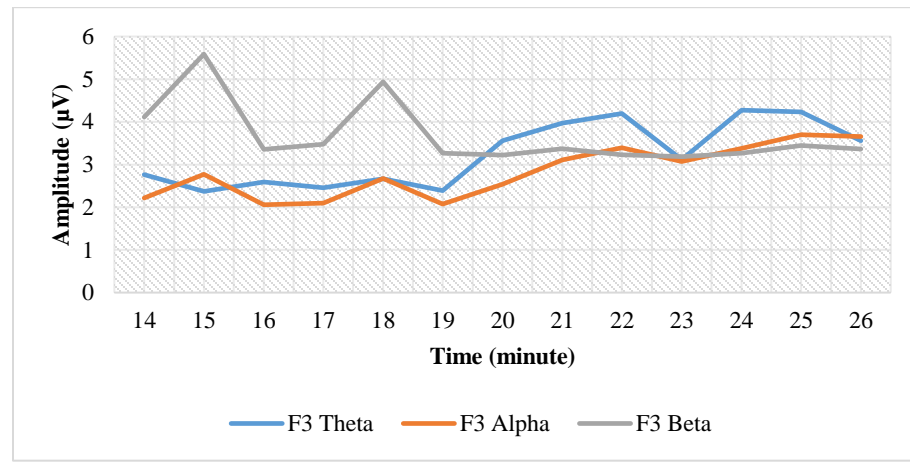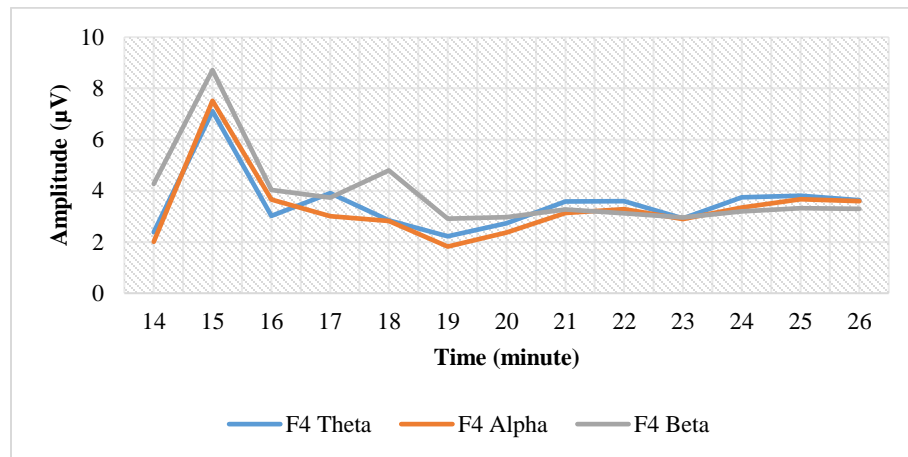

Figure 4.60 RMS Graphic on Respondent 1 at P3 by non-autodidact in the afternoon

Figure 4.61 shows the amplitude RMS graphic of first respondent's EEG final signal on non-autodidact in the afternoon at P4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 19th minute, where the value of Beta, Theta, and Alpha amplitude was 2.7090, 2.4481, and 2.0273 µv at the 19th minute. Then, the amplitude of Theta increased at 20th minute whereas the amplitude of Beta was the lowest among others. The value of Theta, Alpha, and Beta amplitude at the 20th minute was 3.0546, 2.1565, and 2.5312 µv.

Figure 4.61 RMS Graphic on Respondent 1 at P4 by non-autodidact in the afternoon

Based on Figure 4.58 and Figure 4.59, the ability of respondent 1 to memorize and solve problems appeared until at the 20th minute. Then at the 21st minute, it decreased and respondent 1 felt sleepy and had no concentration. As well as shown on Figure 4.60 and Figure 4.61, the ability of respondent 1 to read and understand the lesson appeared until at the 19th minute. Then at the 20th minute, it decreased and respondent 1 felt sleepy. It indicated that respondent 1 had not focussed on Physics subject at the 21st minute during studying on non-autodidact in the afternoon.

b.   Respondent 2

Figure 4.62 shows the amplitude RMS graphic of second respondent's EEG final signal on non-autodidact in the afternoon at F3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 38th minute, where the value of Beta, Theta, and Alpha amplitude was 5.4506, 2.4180, 3.7837 µv at the 8th minute. Then, the amplitude of Theta increased at the 39th minute whereas the amplitude of Beta was the lowest among others. The value of Theta, Alpha, and Beta amplitude at the 39th minute was 5.0342, 4.1434, and 4.1370 µv.
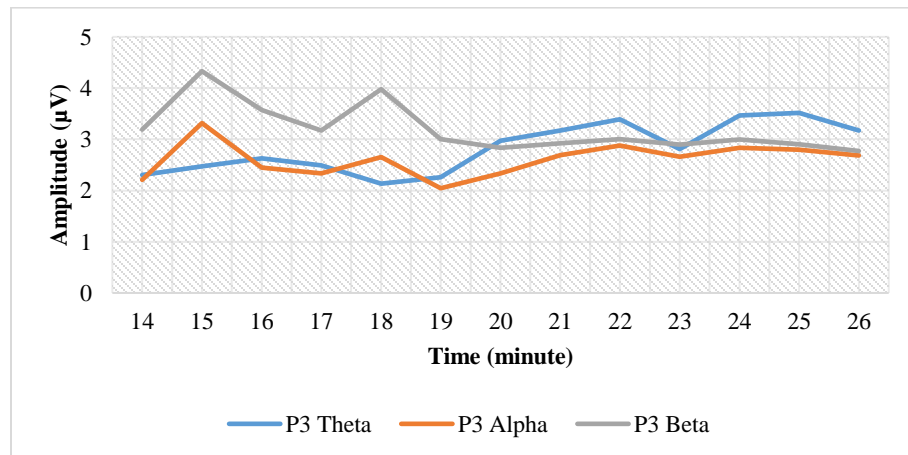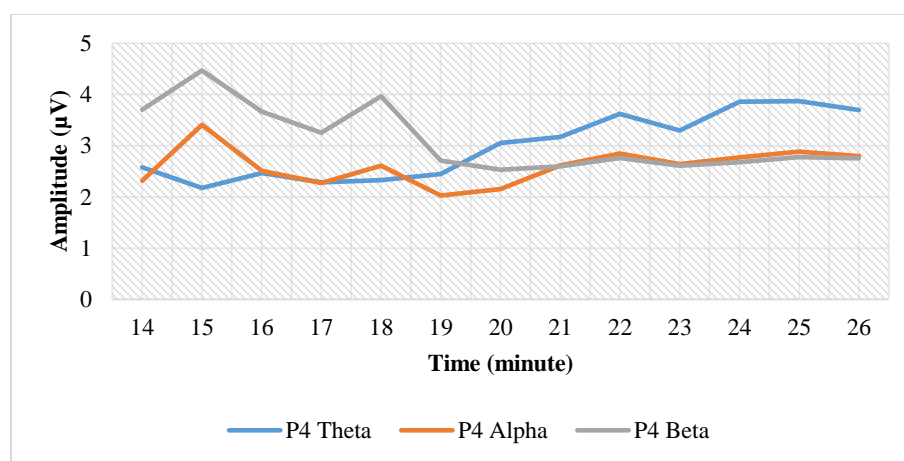

Figure 4.62 RMS Graphic on Respondent 2 at F3 by non-autodidact in the afternoon

Figure 4.63 shows the amplitude RMS graphic of second respondent's EEG final signal on non-autodidact in the afternoon at F4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 35th minute, where the value of Beta, Theta, and Alpha amplitude was 3.4522, 2.7869, and 3.2441 µv at the 35th minute. Then, the amplitude of Alpha at the 36th minute (3.8988 µv) continued increasing and the highest among Theta (2.6614 µv) and Beta (3.6941 µv). Furthermore, it followed with the increasing of Theta amplitude at the 42nd minute (15.9908 µv) which was the greatest among Alpha (11.1126 µv) and Beta (9.5930 µv).

Figure 4.63 RMS Graphic on Respondent 2 at F4 by non-autodidact in the
afternoon

Figure 4.64 shows the amplitude RMS graphic of second respondent's EEG
final signal on non-autodidact in the afternoon at P3 channel. It shows that
amplitude of Beta was the greatest compare to Theta and Alpha until at the 32nd
minute, where the value of Beta, Theta, and Alpha amplitude was 3.6124, 2.6404,
and 3.2586 µv at the 32nd minute. Then, the amplitude of Alpha at the 33rd minute
(4.1830 µv) continued increasing and the highest among Theta (2.3850 µv) and
Beta (2.9895 µv). Furthermore, it followed with the increasing of Theta amplitude
at the 42nd minute (15.4954 µv) which was the greatest among Alpha (10.9037 µv)
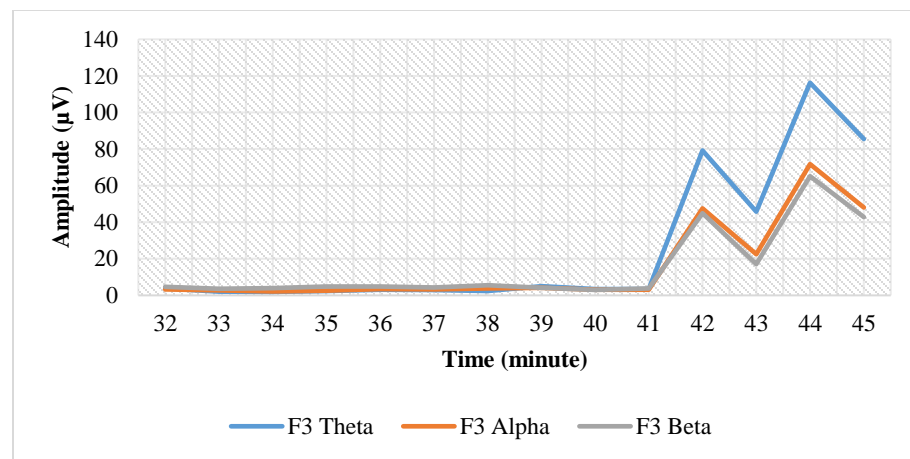and Beta (9.6135 µv).

Figure 4.64 RMS Graphic on Respondent 2 at P3 by non-autodidact in the afternoon

Figure 4.67 shows the amplitude RMS graphic of second respondent's EEG final signal on non-autodidact in the afternoon at P4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 32nd minute, where the value of Beta, Theta, and Alpha amplitude was 3.4079, 2.2729, and 2.5711 µv at the 32nd minute. Then, the amplitude of Alpha at the 33rd minute (3.0892 µv) continued increasing and the highest among Theta (1.8611 µv) and Beta (2.5775 µv). Furthermore, it followed with the increasing of Theta amplitude at the 42nd minute (14.6079 µv) which was the greatest among Alpha (9.9631 µv) and Beta (8.7888 µv).
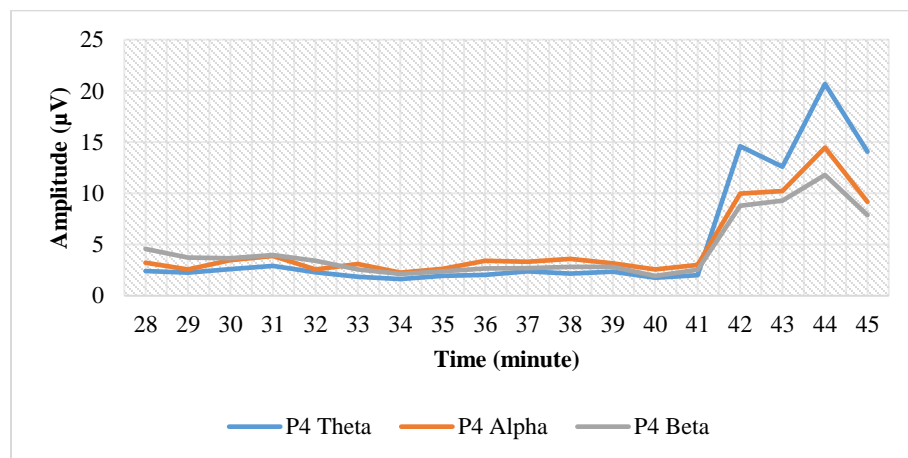
Figure 4.65 RMS Graphic on Respondent 2 at P4 by non-autodidact in the afternoon

Based on Figure 4.62 and Figure 4.63, the ability of respondent 2 to memorize and solve problems appeared until at the 38th minute. Then at the 39th minute, it decreased and respondent 2 had no concentration and felt sleepy. As well as shown on Figure 4.64 and Figure 4.65, the ability of respondent 2 to read and understand the lesson appeared until at the 32nd minute. Then at the 33rd minute, it decreased and respondent 2 had no concentration and felt sleepy. It indicated that respondent 2 had not focussed on Physics subject at the 39th minute during studying on non-autodidact in the afternoon.

c.   Respondent 3

Figure 4.66 shows the amplitude RMS graphic of third respondent's EEG final signal on non-autodidact in the afternoon at F3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 30th minute, where the value of Beta, Theta, and Alpha amplitude was 3.1792, 2.7329, and 2.9505 µv at the 30th minute. Then, the amplitude of Theta increased at 31st minute where Theta was predominant the highest among others after the 31st minute. The value of Theta, Alpha, and Beta amplitude at the 31st minute was 5.7512, 2.9260, and 2.9382 µv.
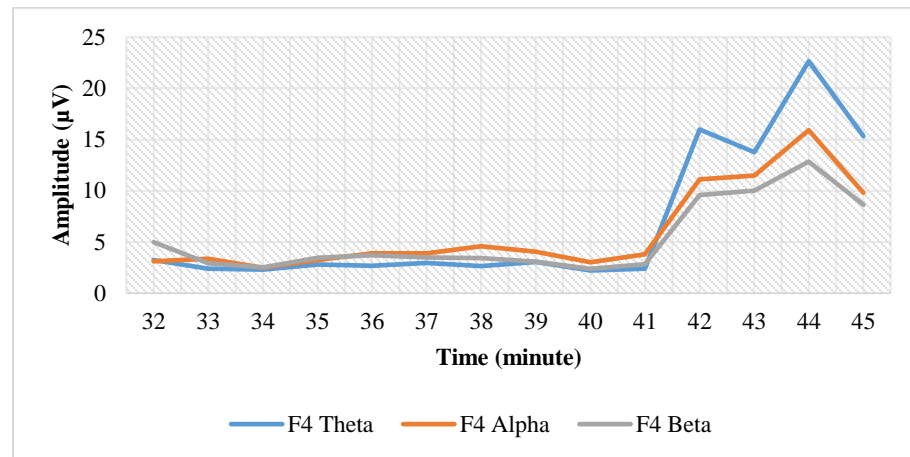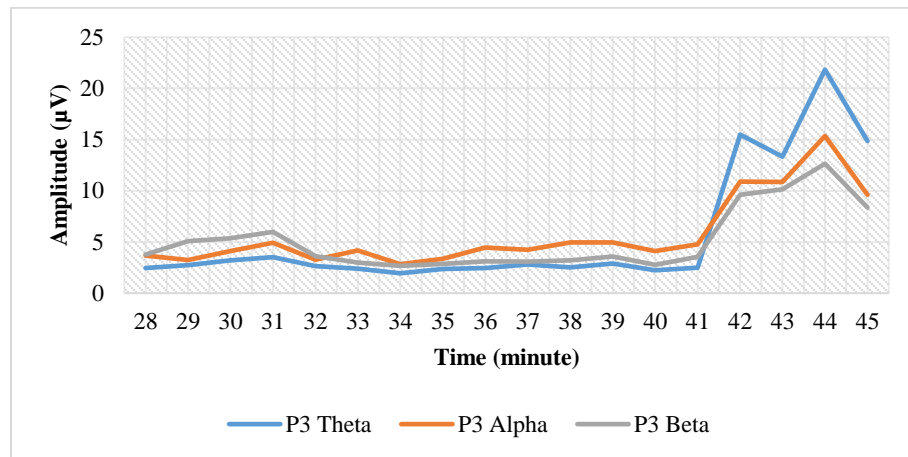

Figure 4.66 RMS Graphic on Respondent 3 at F3 by non-autodidact in the afternoon

Figure 4.67 shows the amplitude RMS graphic of third respondent's EEG final signal on non-autodidact in the afternoon at F4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 29th minute, where the value of Beta, Theta, and Alpha amplitude was 2.9276, 2.4683, and 2.3273 µv at the 29th minute. Then, the amplitude of Theta and Alpha increased at 30th minute where Theta was predominant higher after the 30th minute. The value of Theta, Alpha, and Beta amplitude at the 30th minute was 4.9681, 2.9081, and 3.1079 µv.

Figure 4.67 RMS Graphic on Respondent 3 at F4 by non-autodidact in the afternoon

Figure 4.68 shows the amplitude RMS graphic of third respondent's EEG final signal on non-autodidact in the afternoon at P3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 29th minute, where the value of Beta, Theta, and Alpha amplitude was 2.5072, 1.6492, and 2.4071 µv at the 29th minute. Then, the amplitude of Theta and Alpha increased at 30th minute where Alpha was predominant higher after the 30th minute. The value of Theta, Alpha, and Beta amplitude at the 30th minute was 4.5232, 3.0707, and 2.9177 µv.
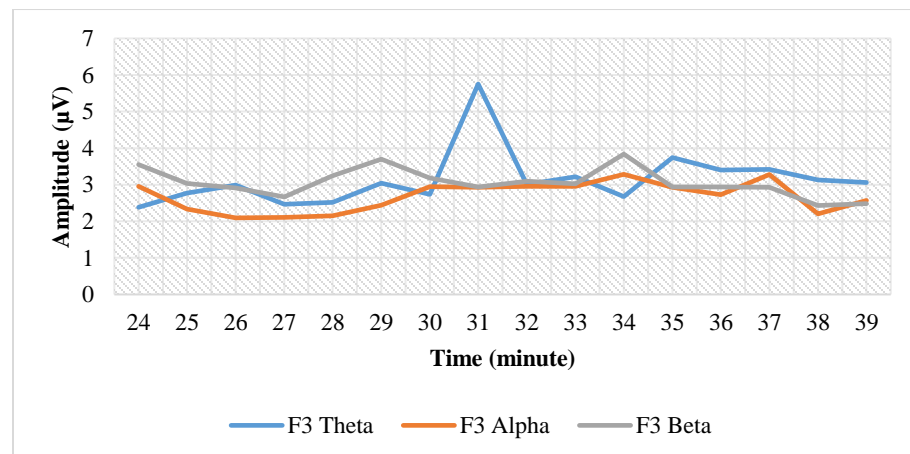
Figure 4.68 RMS Graphic on Respondent 3 at P3 by non-autodidact in the
afternoon

Figure 4.69 shows the amplitude RMS graphic of third respondent's EEG
final signal on non-autodidact in the afternoon at P4 channel. It shows that
amplitude of Beta was the greatest compare to Theta and Alpha until at the 29th
minute, where the value of Beta, Theta, and Alpha amplitude was 2.5929, 1.7397,
and 2.4292 µv at the 29th minute. Then, the amplitude of Theta and Alpha increased
at 30th minute where Alpha was predominant higher after the 30th minute. The
value of Theta, Alpha, and Beta amplitude at the 30th minute was 4.2243, 2.9057,
and 2.9428 µv.
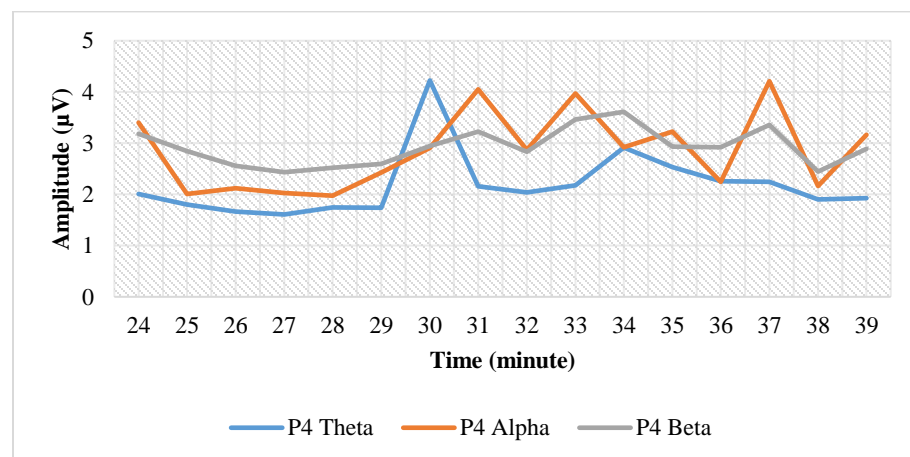
Figure 4.69 RMS Graphic on Respondent 3 at P4 by non-autodidact in the
afternoon

Based on Figure 4.66 and Figure 4.67, the ability of respondent 3 to memorize and solve problems appeared until at the 30th minute. Then at the 31st minute, it decreased and respondent 3 felt sleepy. As well as shown on Figure 4.68 and Figure 4.69, the ability of respondent 3 to read and understand the lesson appeared until at the 29th minute. Then at the 30th minute, it decreased and respondent 3 had no concentration and felt sleepy. It indicated that respondent 3 had not focussed on Physics subject at the 31st minute during studying on non-autodidact in the afternoon.

d.   Respondent 4

Figure 4.70 shows the amplitude RMS graphic of fourth respondent's EEG final signal on non-autodidact in the afternoon at F3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 21st minute, where the value of Beta, Theta, and Alpha amplitude was 6.2334, 4.1770, 5.6795 µv at the 21st minute. Then, the amplitude of Theta and Alpha increased at the 22nd minute where Alpha was predominant higher after the 22nd minute. The value of Theta, Alpha, and Beta amplitude at the 22nd minute was 3.8766, 3.6335, and 3.6802 µv.
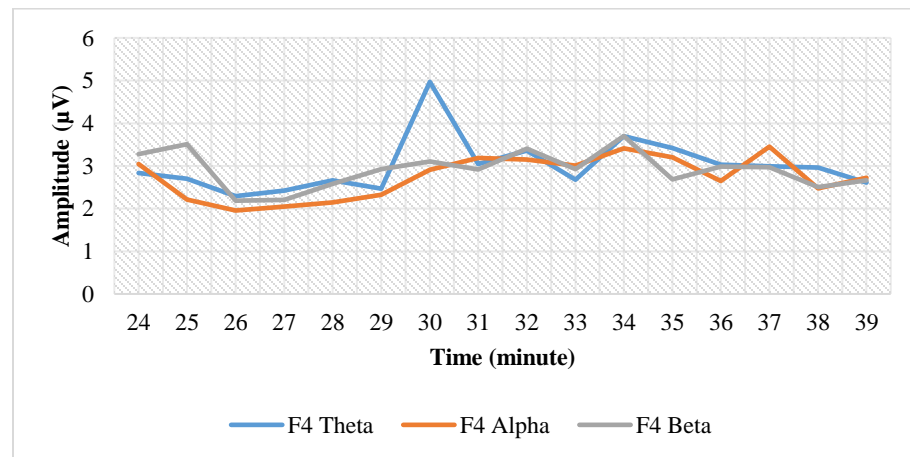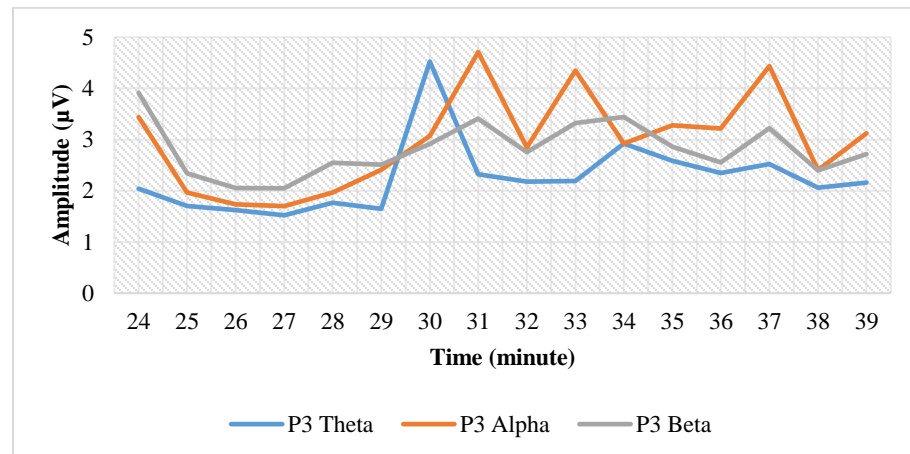

Figure 4.70 RMS Graphic on Respondent 4 at F3 by non-autodidact in the afternoon

Figure 4.71 shows the amplitude RMS graphic of fourth respondent's EEG final signal on non-autodidact in the afternoon at F4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 21st minute, where the value of Beta, Theta, and Alpha amplitude was 5.0142, 4.8391, and 5.2399 µv at the 21st minute. Then, the amplitude of Theta and Alpha increased at the 22nd minute where Theta was predominant higher after the 22nd minute. The value of Theta, Alpha, and Beta amplitude at the 22nd minute was 23.3584, 15.1817, and 16.4712 µv.

Figure 4.71 RMS Graphic on Respondent 4 at F4 by non-autodidact in the afternoon

Figure 4.72 shows the amplitude RMS graphic of fourth respondent's EEG final signal on non-autodidact in the afternoon at P3 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 22nd minute, where the value of Beta, Theta, and Alpha amplitude was 5.2619, 4.2479, and 4.0489 µv at the 22nd minute. Then, the amplitude of Theta and Alpha increased at the 23rd minute where Theta was predominant higher after the 23rd minute. The value of Theta, Alpha, and Beta amplitude at the 23rd minute was 3.7223, 2.8228, and 3.5166 µv.
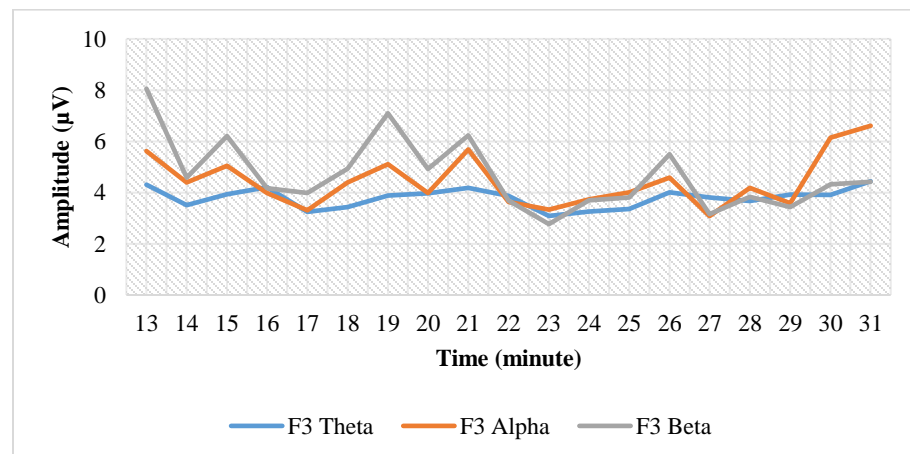
Figure 4.72 RMS Graphic on Respondent 4 at P3 by non-autodidact in the afternoon

Figure 4.73 shows the amplitude RMS graphic of fourth respondent's EEG final signal on non-autodidact in the afternoon at P4 channel. It shows that amplitude of Beta was the greatest compare to Theta and Alpha until at the 21st minute, where the value of Beta, Theta, and Alpha amplitude was 5.9156, 3.881, 5.0525 µv at the 21st minute. Then, the amplitude of Theta and Alpha increased at the 22nd minute where Alpha was predominant higher after 22nd minute. The value of Theta, Alpha, and Beta amplitude at the 22nd minute was 5.8108, 5.0831, and 5.5946 µv.
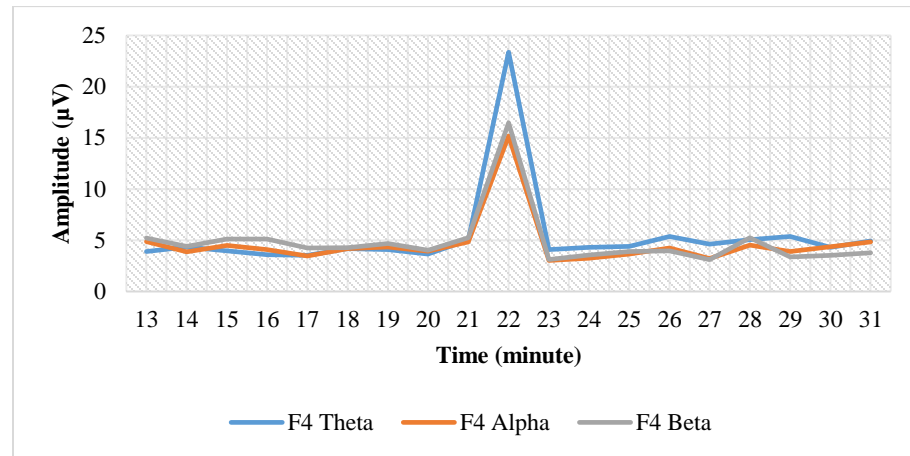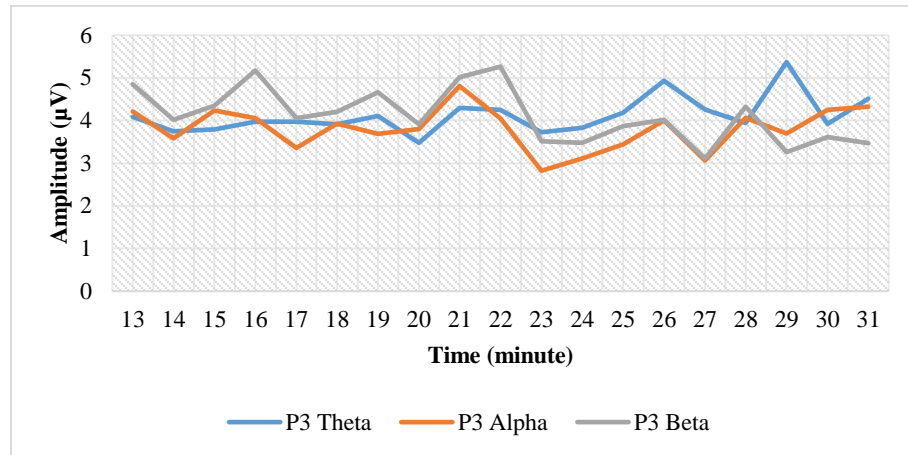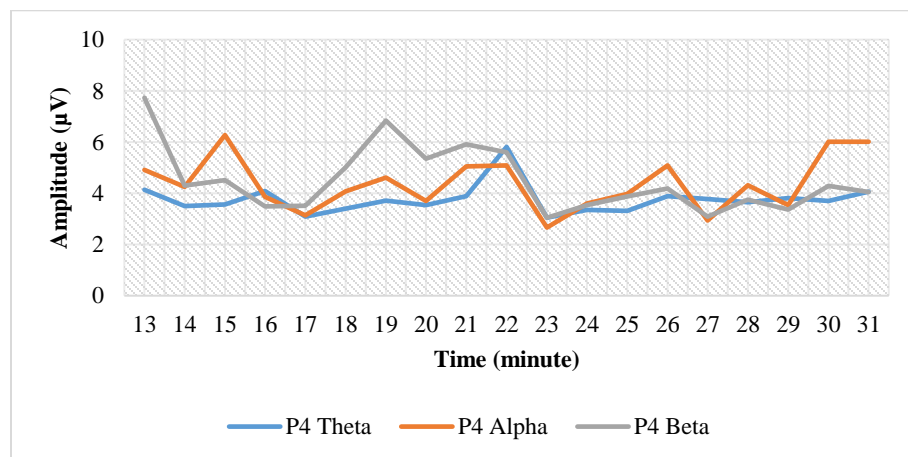

Figure 4.73 RMS Graphic on Respondent 4 at P4 by non-autodidact in the afternoon

Based on Figure 4.70 and Figure 4.71, the ability of respondent 4 to memorize and solve problems appeared until at the 21st minute. Then at the 22nd minute, it decreased and respondent 4 had no concentration and felt sleepy. As well as shown on Figure 4.72 and Figure 4.73, the ability of respondent 4 to read and understand the lesson appeared until at the 22nd minute. Then at the 23rd minute, it decreased and respondent 4 had no concentration and felt sleepy. It indicated that respondent 4 had not focussed on Physics subject at the 23rd minute during studying on non-autodidact in the afternoon.

4.2.3   EARLY TIME FOR THE INCREASING OF THETA AND ALPHA

According to RMS graphic on each respondent at each session, it resulted that early time is considered as a time when respondent has not been focussed. Early time for the Increasing of Theta and Alpha shows in Table 4.3 below.

Table 4.3 Early Time for the Increasing of Theta and Alpha

Respondent	Autodidact		Non-Autodidact	
	Late Morning (at…minute)	Afternoon (at…minute)	Late Morning (at…minute)	Afternoon (at…minute)
S1	50th	34th	82nd	21st
S2	48th	31st	57th	39th
S3	61st	27th	66th	31st
S4	58th	25th	58th	23rd
Average	**54.25^{th}**	**29.25^{th}**	**65.75^{th}**	**28.5^{th}**

4.2.4 RESULT OF STATISTICAL TEST

4.2.4.1 Wilcoxon Signed Rank Test for Result Final Score

Non-parametric statistical analysis of Wilcoxon Signed Rank test was used to demonstrate the difference between the independent samples of the study. On this study, the independent samples were divided into learning method and condition of result final score. Final score of study was gotten based on the correct answer toward 10 questions offered after each session which shows on Table 4.2 above. The Wilcoxon Signed Rank test was conducted to testify the significant difference between both data.

a. Between late morning and afternoon condition on autodidact learning method
   Based on Table 4.2 that shows the score of Physic subject especially on Electromagnetic Induction subchapter, Wilcoxon Signed Rank test to demonstrate the difference between late morning and afternoon condition on autodidact learning method was conducted. The input for variable 1 is autodidact in the late morning final score data, then variable 2 is autodidact in the afternoon final score data. The output is shown in Table 4.4 below.

Table 4.4 Wilcoxon Signed Rank Test for Result Final Score on Autodidact Learning Method

Result Final Score on Autodidact Learning Method	
Asymp. Sig. (2-tailed)	0.059
Negative Ranks	4
Positive Ranks	0
Ties	0

Based on Table 4.4 above, it is shown that all final score data for autodidact in the afternoon (input variable 2) were lower than autodidact in the morning (input variable 1). Then, the result of Wilcoxon Signed Rank test is Asymp. Sig. (2-tailed)

> 0.05. It means that result final score on autodidact learning method between late morning and afternoon condition is not significantly different.

b. Between late morning and afternoon condition on non-autodidact learning method

Based on Table 4.2 that shows the score of Physic subject especially on Electromagnetic Induction subchapter, Wilcoxon Signed Rank test to demonstrate the difference between late morning and afternoon condition on non-autodidact learning method was conducted. The input for variable 1 is non-autodidact in the late morning final score data, then variable 2 is non-autodidact in the afternoon final score data. The output is shown in Table 4.5 below.

Table 4.5 Wilcoxon Signed Rank Test for Result Final Score on Non-Autodidact Learning Method

Result Final Score on Non-Autodidact Learning Method	
Asymp. Sig. (2-tailed)	0.102
Negative Ranks	3
Positive Ranks	0
Ties	1

Based on Table 4.5 above, it is shown that 3 final data of non-autodidact in the afternoon (input variable 2) were lower than non-autodidact in the late morning (input variable 1), while remain was ties. The result of Wilcoxon Signed Rank test is Asymp. Sig. (2-tailed) > 0.05. It means that result final score on non-autodidact learning method between late morning and afternoon condition is not significantly different.

c. Between autodidact and non-autodidact learning method in the late morning condition

Based on Table 4.2 that shows the score of Physic subject especially on Electromagnetic Induction subchapter, Wilcoxon Signed Rank test to demonstrate the difference between late autodidact and non-autodidact learning method in the late morning condition was conducted. The input for variable 1 is autodidact in the

late morning final score data, then variable 2 is non-autodidact in the late morning final score data. The output is shown in Table 4.6 below.

Table 4.6 Wilcoxon Signed Rank Test for Result Final Score in the Late Morning Condition

Result Final Score in the Late Morning Condition	
Asymp. Sig. (2-tailed)	0.109
Negative Ranks	3
Positive Ranks	0
Ties	1

Based on Table 4.6 above, it is shown that 3 final data of non-autodidact in the late morning (input variable 2) were lower than autodidact in the late morning (input variable 1), while remains were ties. The result of Wilcoxon Signed Rank test is Asymp. Sig. (2-tailed) > 0.05. It means that result final score in the late morning condition between autodidact and non-autodidact learning method is not significantly different.

d. Between autodidact and non-autodidact learning method in the afternoon condition
Based on Table 4.2 that shows the score of Physic subject especially on Electromagnetic Induction subchapter, Wilcoxon Signed Rank test to demonstrate the difference between late autodidact and non-autodidact learning method in the afternoon condition was conducted. The input for variable 1 is autodidact in the afternoon final score data, then variable 2 is non-autodidact in the afternoon final score data. The output is shown in Table 4.7 below.

Table 4.7 Wilcoxon Signed Rank Test for Result Final Score in the Afternoon Condition

Result Final Score in the Afternoon Condition	
Asymp. Sig. (2-tailed)	0.180
Negative Ranks	2
Positive Ranks	0
Ties	2

Based on Table 4.7 above, it is shown that 3 final data of non-autodidact in the afternoon (input variable 2) were lower than autodidact in the afternoon (input variable 1), while remain was ties. The result of Wilcoxon Signed Rank test is Asymp. Sig. (2-tailed) > 0.05. It means that result final score in the afternoon condition between autodidact and non-autodidact learning method is not significantly different.

4.2.4.2   Wilcoxon Signed Rank Test on Early Time for the Increasing of Theta and Alpha

Non-parametric statistical analysis of Wilcoxon Signed Rank test was used to demonstrate the difference between the independent samples of the study. On this study, the independent samples were divided into learning method and condition on early time for the increasing of Theta and Alpha. Early time for the increasing of Theta and Alpha was gotten from RMS calculation on each respondent at each session that shows at Table 4.3. The Wilcoxon Signed Rank test was conducted to testify the significant difference between both data.

a. Between late morning and afternoon condition on autodidact learning method
   Based on Table 4.3 that shows the early time for the increasing of Theta and Alpha, Wilcoxon Signed Rank test to demonstrate the difference between late morning and afternoon condition on autodidact learning method was conducted. The input for variable 1 is autodidact in the late morning data of early time for increasing theta and alpha, then variable 2 is autodidact in the afternoon data of early time for increasing theta and alpha. The output is shown in Table 4.8 below.

Table 4.8 Wilcoxon Signed Rank Test (Early Time for the Increasing of Theta and Alpha on Autodidact Learning Method)

Early Time for the Increasing of Theta and Alpha on Autodidact Learning Method	
Asymp. Sig. (2-tailed)	0.068
Negative Ranks	4
Positive Ranks	0
Ties	0

Based on Table 4.8 above, it is shown that all of data on autodidact in the afternoon (input variable 2) were lower than autodidact in the late morning data (input variable 1). The result of Wilcoxon Signed Rank test is Asymp. Sig. (2-tailed) < 0.05. It means that early time for the increasing of Theta and Alpha on autodidact learning method between late morning and afternoon condition is not significantly different.

b. Between late morning and afternoon condition on non-autodidact learning method

Based on Table 4.3 that shows the early time for the increasing of Theta and Alpha, Wilcoxon Signed Rank test to demonstrate the difference between late morning and afternoon condition on non-autodidact learning method was conducted. The input for variable 1 is non-autodidact in the late morning data of early time for increasing theta and alpha, then variable 2 is non-autodidact in the afternoon data of early time for increasing theta and alpha. The output is shown in Table 4.9 below.

Table 4.9 Wilcoxon Signed Rank Test (Early Time for the Increasing of Theta and Alpha on Non-Autodidact Learning Method)

Early Time for the Increasing of Theta and Alpha on Non-Autodidact Learning Method	
Asymp. Sig. (2-tailed)	0.066
Negative Ranks	4
Positive Ranks	0
Ties	0

Based on Table 4.9 above, it is shown that all of data on non-autodidact in the afternoon (input variable 2) were lower than non-autodidact in the afternoon data

(input variable 1). The result of Wilcoxon Signed Rank test is Asymp. Sig. (2-tailed) > 0.05. It means that early time for the increasing of Theta and Alpha on non-autodidact learning method between late morning and afternoon condition is not significantly different.

c. Between autodidact and non-autodidact learning method in the late morning condition

Based on Table 4.3 that shows the early time for the increasing of Theta and Alpha, Wilcoxon Signed Rank test to demonstrate the difference between autodidact and non-autodidact learning method in the late morning condition was conducted. The input for variable 1 is autodidact in the late morning data of early time for increasing theta and alpha, then variable 2 is non-autodidact in the late morning data of early time for increasing theta and alpha. The output is shown in Table 4.10 below.

Table 4.10 Wilcoxon Signed Rank Test (Early Time for the Increasing of Theta and Alpha in the Late Morning Condition)

Early Time for the Increasing of Theta and Alpha in the Late Morning Condition	
Asymp. Sig. (2-tailed)	0.109
Negative Ranks	0
Positive Ranks	3
Ties	1

Based on Table 4.10 above, it is shown that 3 data on non-autodidact in the late morning (input variable 2) were higher than autodidact in the late morning data (input variable 1), while remain was ties. The result of Wilcoxon Signed Rank test is Asymp. Sig. (2-tailed) > 0.05. It means that early time for the increasing of Theta and Alpha in the late morning condition between autodidact and non-autodidact learning method is not significantly different.

d. Between autodidact and non-autodidact learning method in the afternoon condition

Based on Table 4.3 that shows the early time for the increasing of Theta and Alpha, Wilcoxon Signed Rank test to demonstrate the difference between autodidact and non-autodidact learning method in the afternoon condition was conducted. The input for variable 1 is autodidact in the afternoon data of early time for increasing theta and alpha, then variable 2 is non-autodidact in the afternoon data of early time for increasing theta and alpha. The output is shown in Table 4.11 below.

Table 4.11 Wilcoxon Signed Rank Test (Early Time for the Increasing of Theta and Alpha in the Afternoon Condition)

Early Time for the Increasing of Theta and Alpha in the Afternoon Condition	
Asymp. Sig. (2-tailed)	1.000
Negative Ranks	2
Positive Ranks	2
Ties	0

Based on Table 4.11 above, it is shown that 2 data on non-autodidact in the afternoon (input variable 2) were lower than autodidact in the afternoon data (input variable 1), while remains were the opposite where 2 data on non-autodidact in the afternoon (input variable 2) were higher than autodidact in the afternoon data (input variable 1). The result of Wilcoxon Signed Rank test is Asymp. Sig. (2-tailed) > 0.05. It means that early time for the increasing of Theta and Alpha in the afternoon condition between autodidact and non-autodidact learning method is not significantly different.