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The Effects of Regular Versus Irregular Caffeine Consumption in Mental Performance

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Caffeine is the most widely used psychoactive drug in the world and is a central nervous system stimulant that increases alertness and excitation. Regular consumption of caffeine can cause one to become dependent on the drug and this, in turn, can cause withdrawal to occur when regular caffeine consumption is disrupted [1]. A case study series (3 cases) addresses the way in which caffeine consumption by regular and irregular caffeine drinkers impacts cognitive performance. Three subjects, 2 regular caffeine drinkers and 1 irregular caffeine drinker, performed case studies to examine the effect of caffeine consumption on their reaction and choice reaction times. A Brain Gauge device and software were used to conduct these cognitive performance tasks. Across all 3 cases, choice reaction time decreased (i.e., task performance improved) after drinking coffee. In most cases, there was a decrease in the average reaction time (performance improvement) after caffeine consumption. The difference in mental performance between regular and irregular drinkers cannot be determined with the results of this case study series. Additional research and experiments with larger sample sizes are needed before making further conclusions about how caffeine consumption and disruption of caffeine consumption affects mental performance.

Citation

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Introduction

Caffeine, the most widely used psychoactive drug, is a central nervous system stimulant that increases alertness and excitation. Caffeine increases excitability in the brain by acting as an adenosine receptor antagonist, which means it blocks receptors to the neurotransmitter adenosine. The brain has multiple receptors that when locked with adenosine, promote relaxation, sleepiness, and cause an interference with the release of mood-enhancing neurotransmitters. When caffeine blocks adenosine receptors, it cannot bind, leading to the feeling of alertness and improved mood [1].

When caffeine is regularly consumed, one can become dependent on the drug. For individuals' dependent on caffeine, disruption of consumption can lead to the experience of caffeine withdrawal. About 12-24 hours after stopping caffeine use, symptoms of caffeine withdrawal can begin [2]. These symptoms include headache, fatigue, anxiety, difficulty concentrating, depressed mood, irritability, tremors, and low energy [1].

Experiments have been investigated assessing how caffeine and caffeine withdrawals impact someone's alertness and performance, specifically one's reaction times. Caffeine withdrawal can often lead to a greater feeling of tiredness, lower performances on memory and reaction time tests

as well as a lower mental alertness [3]. In an experiment, subjects (age 18-62) were given caffeine on some days and not on other days. The subjects completed memory and reaction time tests and the results were compared and analyzed. This experiment determined that caffeine improved most participants' motor performance, however, it led to increased anxiety and jitteriness [3]. The experiment to be discussed is focused on specifically analyzing college students and assessing if caffeine has an effect on reaction time and choice reaction time.

In addition, another research article that was investigated focused on how caffeine affects one's reaction time which was studied through one's Taekwondo performance. The reaction time on kick tests was assessed during two successive rounds [4]. It was determined that the intensity of the kick was not impacted by the caffeine, but the reaction time was smaller in successive rounds [4]. This is significant to the experiment as the expectation is to see coffee decrease one's reaction time and increase someone's jitteriness. Although the reaction time will be monitored through the Brain Gauge, a connection between the physical Taekwondo reaction time experiment and this experiment are seen, which leads the investigators to expect to see similar results regarding caffeine.

In the case studies reported here, the effects of caffeine on mental performance (reaction time and choice reaction time) using the Brain Gauge were evaluated, and the cases included subjects that regularly consumed caffeine and subjects that did not. Determination of caffeine use in each case study was done via a survey prior to the study, and the participants took a survey about how they feel before the consumption of a specific amount of caffeine (coffee) and repeated these surveys 30-60 minutes after caffeine consumption. Reaction time tasks were also tracked with the Brain Gauge.

Methods

This case study series consists of 3 subjects, 2 of which are considered regular caffeine consumers who both consume coffee on a daily basis and 1 of which is not considered a regular caffeine consumer who consumes coffee or espresso once to twice a month. Each subject answered a brief survey before beginning the study to determine their normal level of caffeine intake. The study consisted of a "Before" survey and Brain Gauge battery, consumption of caffeine, then an "After" survey and Brain Gauge battery. Both surveys and Brain Gauge batteries consisted of the same information and tests. The "Before" protocol was completed by each subject before consuming any caffeine at the beginning of their day. The time, level of alertness, hours of sleep, and level of jitteriness were recorded, then reaction time and choice reaction time tests were performed using the Brain Gauge. For these Brain Gauge tests, the subject was advised to sit at a table or desk with the Brain Gauge device on a flat surface. Their dominant hand was placed on the device, then the battery was started. The reaction time test consisted of the middle finger tick vibrating at various times, then the subject clicked the index finger tick as soon as the vibration was felt. The choice reaction time test consisted of either the index or middle finger tick vibrating, then the subject clicked the tick that did not vibrate. The results of both tests are then recorded and can be analyzed within the Brain Gauge application. The subject then consumed caffeine, the amount and type were recorded in the survey, which consisted of either coffee or espresso for each subject. Approximately 60 minutes after consumption, the subject performed the "After" protocol, the same survey and battery of tests as before.

Results

Subject 1 is considered a regular caffeine drinker, consuming on average 136mg of caffeine a day, which normally comes from 12oz of black coffee. This subject completed the case study for 7 days, beginning at approximately 8am and completing the final protocol at 9:30am. A 30-minute walk was completed before completing each initial protocol and the average amount of sleep the subject recorded was 7.2 hours per night.

Results of the reaction time and choice reaction time tests were recorded with the Brain Gauge application and then a spreadsheet of the data was collected. The average reaction time before caffeine consumption for this subject, excluding the first day due to hardware difficulties, was 262.9 ms. The average reaction time after consumption was 239.2 ms. The average percent decrease in reaction time, or increase in speed, is approximately 9.00%. This percentage was calculated by subtracting 1 from the average reaction time after consumption of caffeine by the average time before consumption. The number was then multiplied by 100. This percentage was calculated for the choice reaction time, as well. Every day in which data was collected, excluding the first day, the reaction time decreased (Figure 1).

Choice reaction time was also recorded and analyzed. The first day of data is also excluded for choice reaction time due to hardware malfunction. The average choice reaction time before consumption was 404.4 ms, and the average time after consumption was 325.8 ms. For 100% of the days, the choice reaction time decreased, with an average decrease of 19.36%. There was a decrease in choice reaction time during all the 6 days recorded (Figure 4).

The survey results, which were recorded as a score from 1-10 from each subject, demonstrated how the subject felt regarding level of energy, sleepiness, alertness, and jitteriness before and after consumption. On average, the level of energy before consumption was 4.86 out of 10, with the level of energy after consumption being on average 7.71 out of 10 (Figure 7). Alertness and jitteriness increased after consumption for each day, while sleepiness decreased (Figure 7). The presence of a headache was also recorded before and after consumption, which showed that 5 out of the 7 days the subject recorded a headache before drinking coffee, then no presence of a headache after drinking coffee.

Subject 2 is considered a regular caffeine consumer and consumes on average 190mg of caffeine a day which is normally from 16oz of black coffee. For this experiment, it is noted that Subject 2 proceeded with their normal caffeine consumption and drank 12oz of black coffee between the “Before” survey and Brain Gauge tests and the “After” protocol. The case study for Subject 2 was completed over the course of 5 days with the subject averaging each night with about 7.1 hours of sleep. The beginning survey was completed between 8:15am-8:45am and the final protocol was completed about 1 hour after the first survey and Brain Gauge test.

The average reaction time before coffee consumption was 303.1ms while the average reaction time after consumption was 335.64ms. Subject 2 increased reaction time meaning they decreased the speed of their reaction after consuming caffeine. The average percent increase in reaction time, or decrease in speed, was determined to be 10.7%. In Figure 2, the reaction time before and after consumption of caffeine fluctuated each day with some days having a higher reaction after consumption and vice versa.

In addition, the average choice reaction time before was determined to be 501.1ms while the averaged choice reaction time after was concluded to be 494.7ms. The averaged percent decrease in choice reaction time was about 1.27%. Similar to Subject 2’s reaction time test, their choice reaction time before and after the consumption of coffee varied for each day (Figure 5).

For the survey results Subject 2 on average had an average level of energy before consumption of 2.80 out of 10 and an average level of energy after consumption of 8.20 out of 10 (Figure 8). The alertness increased from an average of 3.80 out of 10 before caffeine consumption to 7.80 out of 10 after caffeine (Figure 8). Jitteriness slightly increased on the scale of 10 from 1.00 before caffeine to 2.30 after consumption (Figure 8). With caffeine consumption, the level of sleepiness saw a decrease with a score average of 5.20 before consumption to a score of 2.20 after (???). Level of energy, alertness, and jitteriness all increased after consumption for, while the level of sleepiness decreased (Figure 8). The subject noted to be experiencing a headache before caffeine consumption on Days 1 and 3. It is noted that there was no presence of a headache following the drinking coffee for these days.

Subject 3 is not classified as a regular caffeine drinker and consumes caffeine about once to twice a month usually by drinking coffee or espresso. The caffeine source for this subject during the experiment was mainly espresso/lattes (specifically 8 ounces of prepackaged Starbucks® Caramel Macchiato) which had an average of 75mg of caffeine. Subject 3 averaged about 6.9 hours of sleep per night. This subject completed the before survey and Brain Gauge between 8:45am-9:00am and completed the after survey roughly one hour after. This case study was completed over the course of 7 days.

The average reaction time decreased during these 7 days by 2.89%. Before the caffeine consumption, the average reaction time for Subject 3 was 252.4 ms and after consumption the average reaction time was 245.1 ms. For 4 out of 7 of the days, the reaction time was shown to decrease after the consumption of caffeine (Figure 3).

In addition, the average choice reaction time also decreased by 19.1% from before to after consumption of caffeine meaning that the choice reaction time got faster after caffeine consumption. The choice reaction time before averaged 544.7 ms for Subject 3 and after consumption the average decreased to 440.7 ms. In Figure 6, the choice reaction time fluctuated before and after consumption. There were two large spikes in the before consumption on Days 2 and 4 for Subject 3 (Figure 6).

Level of energy, alertness, and jitteriness all increased after consumption, while the level of sleepiness decreased for Subject 3 over the course of 7 days (Figure 9). Subject 3 averaged at 4.93 out of 10 for level of energy before consumption and had an average level of energy after consumption of 6.71 out of 10 (Figure 9). The alertness of Subject 3 increased from an average of 6.28 out of 10 before caffeine consumption to 8.21 out of 10 after caffeine (Figure 8). Jitteriness nearly tripled from before to consumption of caffeine to after (???). Specifically, the jitteriness before caffeine was a score of 1.71 out of 10 to 4.50 after consumption (Figure 8). With caffeine consumption, the level of sleepiness saw a slight decrease with a score average of 3.29 before consumption to a score of 2.35 after (Figure 9). The subject noted to be experiencing a headache before caffeine consumption only on Day 1 which persisted following drinking coffee.

Discussion

The data collected in this experiment for Subject 1 was consistent with literature regarding the effect of caffeine and caffeine withdrawal on reaction time and overall mental performance. Subject 1 was considered a regular caffeine drinker, consuming at least 12 oz of caffeine in the form of coffee or espresso each day. Reaction and choice reaction times were consistently longer before caffeine consumption for this subject, while reaction and choice reaction times were quicker after consumption. Subject 2 was also considered a regular caffeine drinker, consuming on average 16 oz of coffee each day. Subject 2 did not show a steady trend in reaction and choice reaction times over the extent of the study for before and after caffeine consumption. Subject 3 was not considered a regular caffeine drinker, consuming caffeine only once or twice a month. This subject did not have consistent trends with reaction and choice reaction time throughout the study.

The average reaction times for subjects 1 and 3 decreased from before consumption to after. Subjects 1 and 3 also had an overall decreased reaction time. This could be contributed to the prior experience with the Brain Gauge, which Subject 2 did not have. From before to after consumption, the average reaction time for Subject 2 increased, or became slower, which was not expected. For all 3 subjects, choice reaction time decreased, or became faster, from before consumption to after consumption. For subjects 1 and 3, the percent decrease in reaction time for choice reaction time was more drastic compared to the reaction time percent decrease. For Subject 2, the 10.7% increase in time, or decrease in speed, was not expected. There was also a significantly lower percentage decrease in choice reaction time for Subject 2. This may possibly be explained due to the lack of experience with the Brain Gauge for Subject 2.

There are many factors to consider that affect a person's mental performance. The timing of the study was not consistent, meaning each subject did not perform the experiment at the same time as the others, and each subject did not perform the experiment at the same time each day. This may affect the scores of the mental performance tests due to the wakefulness of the subject at the time of the experiment. Experience with usage of the Brain Gauge software and equipment also differed with the subjects, with Subject 1 and 3 having 2.5 months of prior experience and Subject 2 having no prior experience. This would have introduced difficulty with using the equipment for Subject 2, affecting the scores. The type of caffeine consumed in the experiment was consistently coffee or espresso, but the sugar content differed. Sugar also can increase energy, which may have had an impact on the mental performance and jitteriness of the subject.

Another important factor to consider would be the amount of sleep the night before for each of the subjects. On average, Subject 1 reported 7.2 hours per night, Subject 2 reported 7.1 hours, and Subject 3 reported 6.9 hours. With this range of average hours of sleep being so small, a wider range in the future could help determine if the amount of sleep had an effect on the mental performance. The morning routine of the 3 subjects should also be taken into consideration in the future, such as activities done before completing the experiment. Other tasks being performed while completing the Brain Gauge tests could also account for drastic changes in the scores for the subjects. In the future, a more controlled environment should be used for the subjects when completing the battery.

Overall, the results of the study suggest that reaction time and choice reaction, on average, decrease, or become faster, after consumption of caffeine. Choice reaction time will consistently be slower than reaction time for all subjects. In order to better conduct this study and make a more accurate conclusion regarding caffeine consumption and mental performance, a larger pool of subjects should be used in a more controlled environment.

Figures

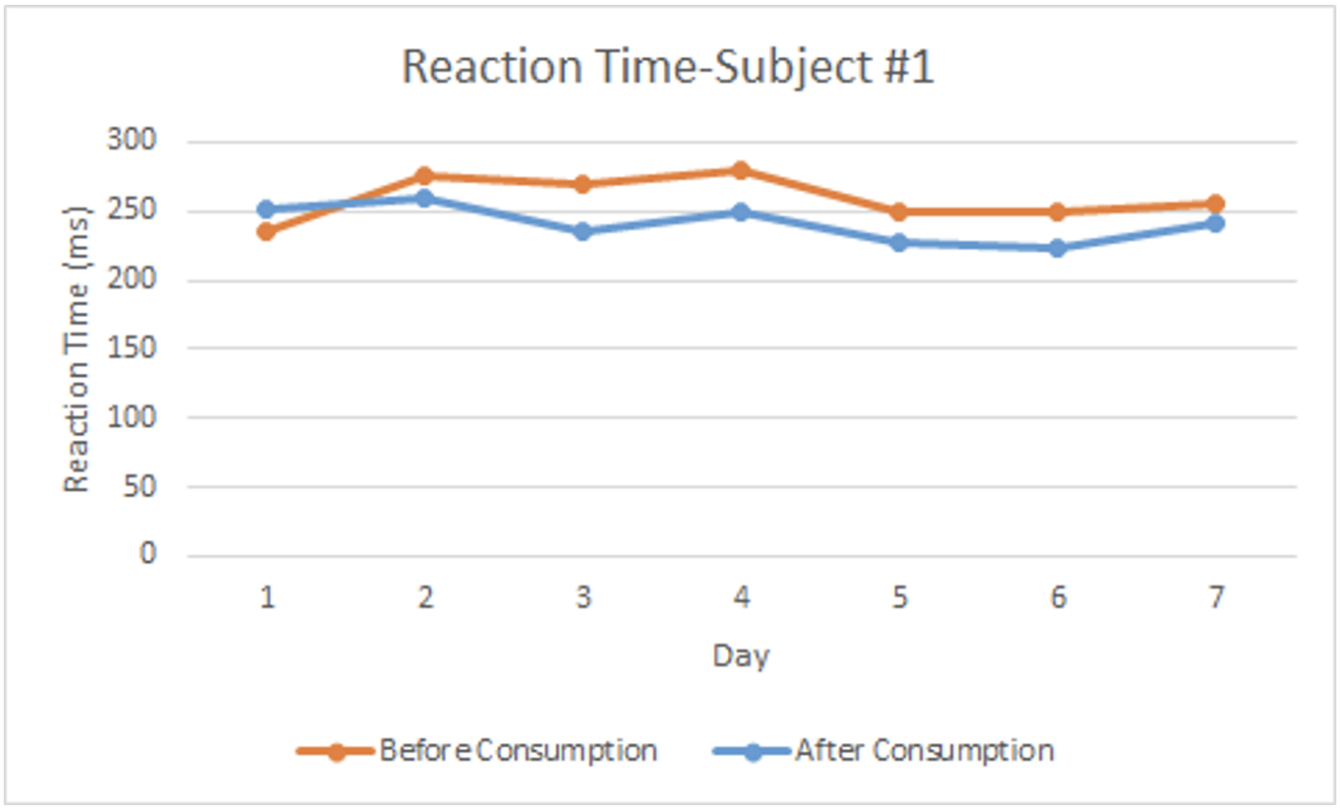

Figure 1. *Reaction Time of Subject #1*

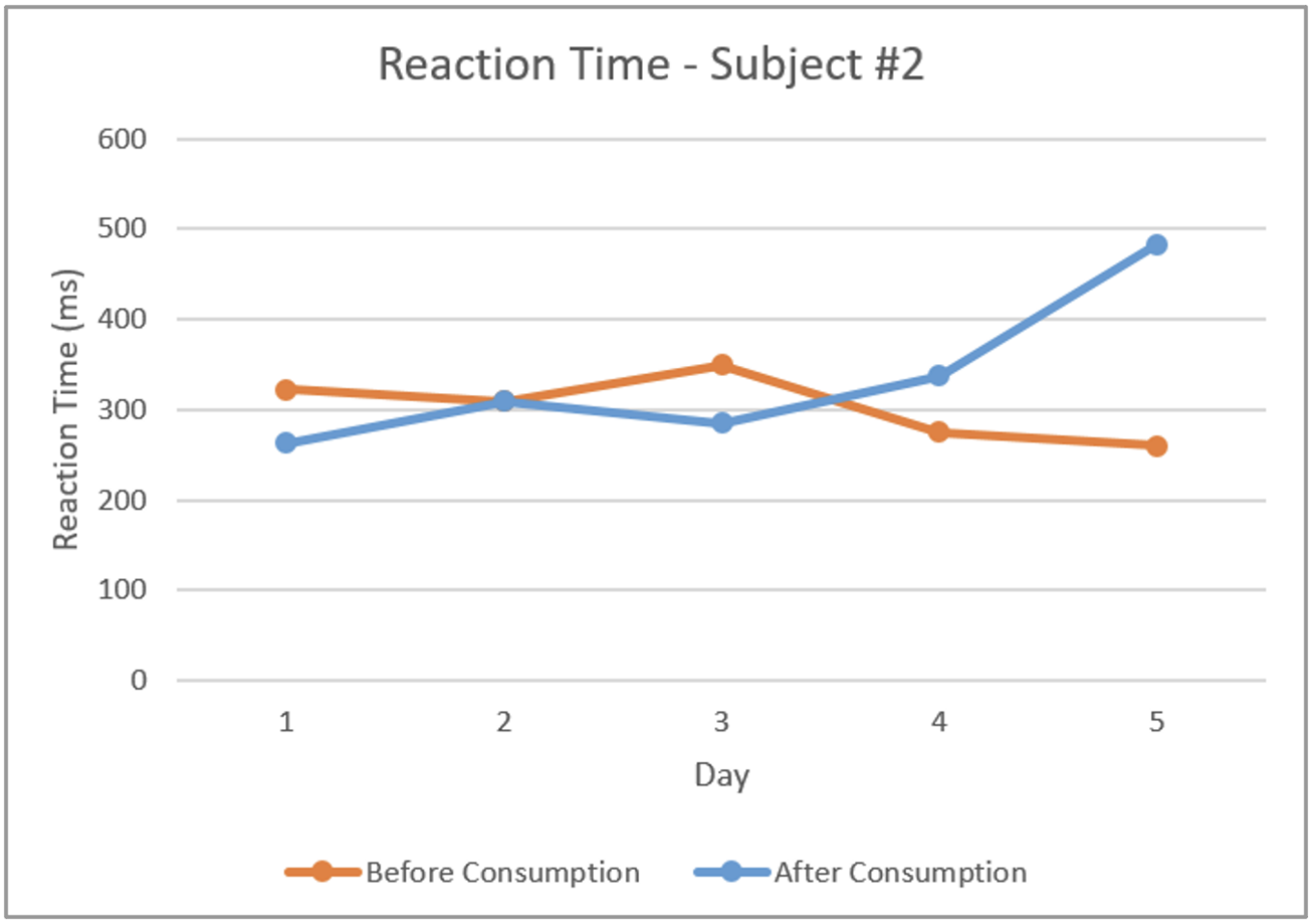

Figure 2. *Reaction Time of Subject #2*

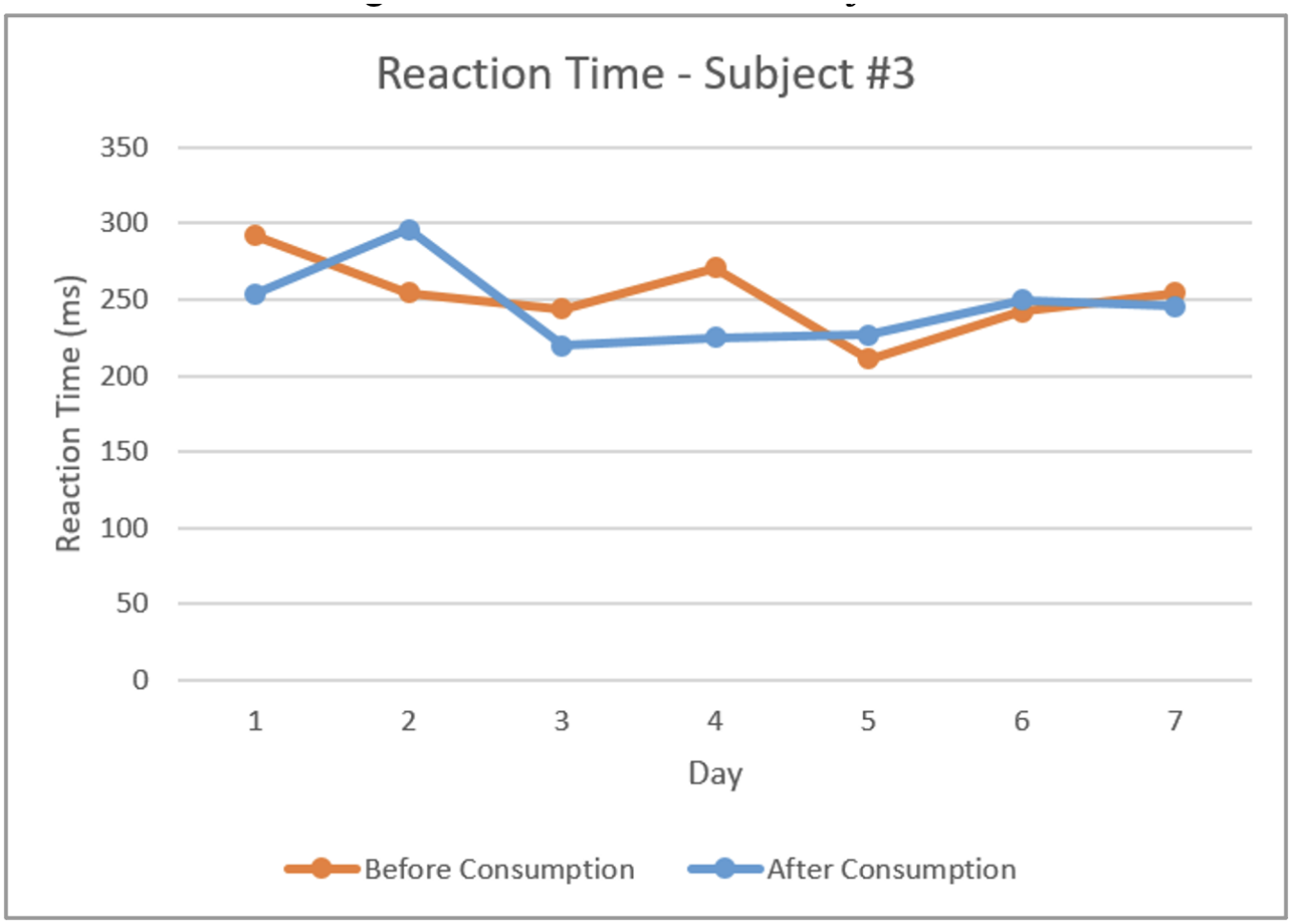

Figure 3. *Reaction Time of Subject #3*

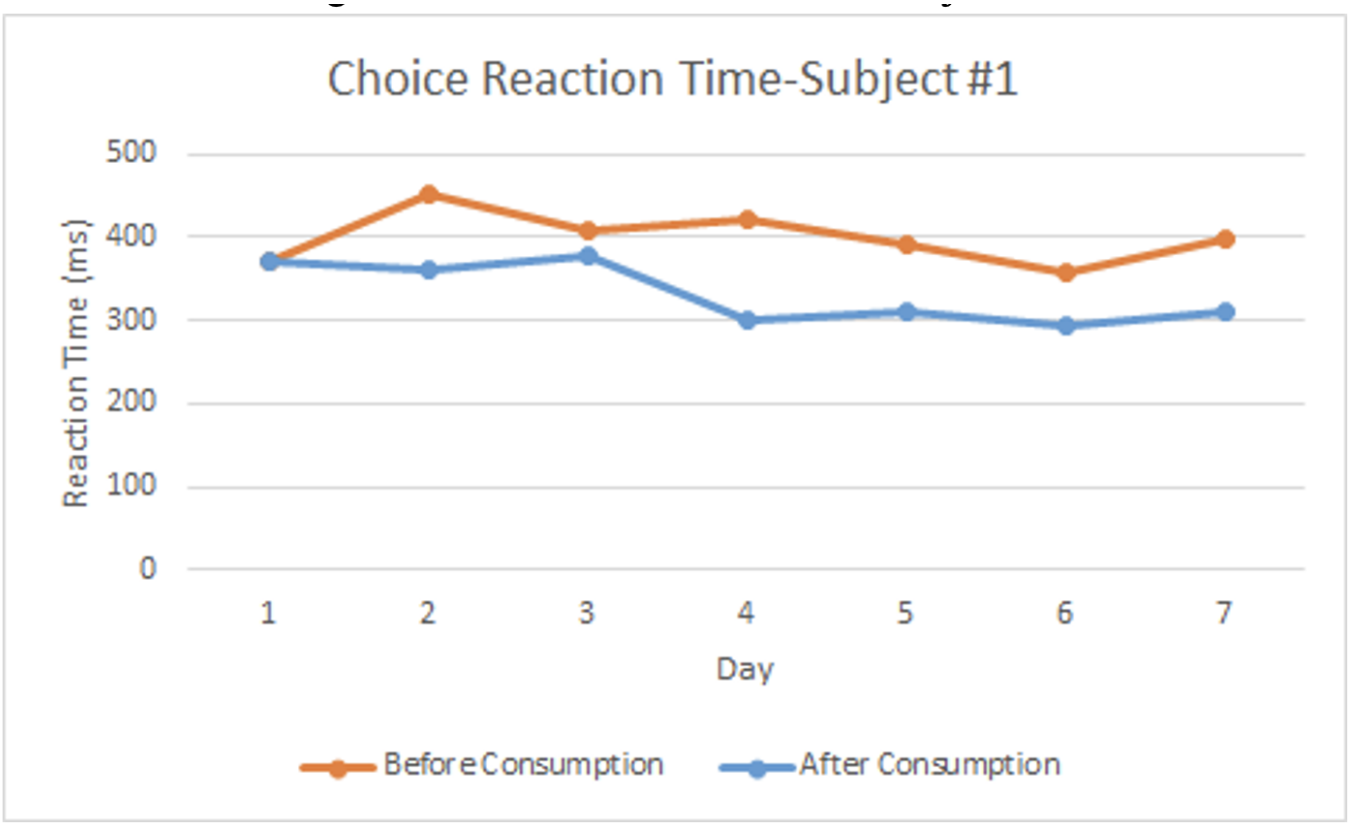

Figure 4. *Choice Reaction Time of Subject #1*

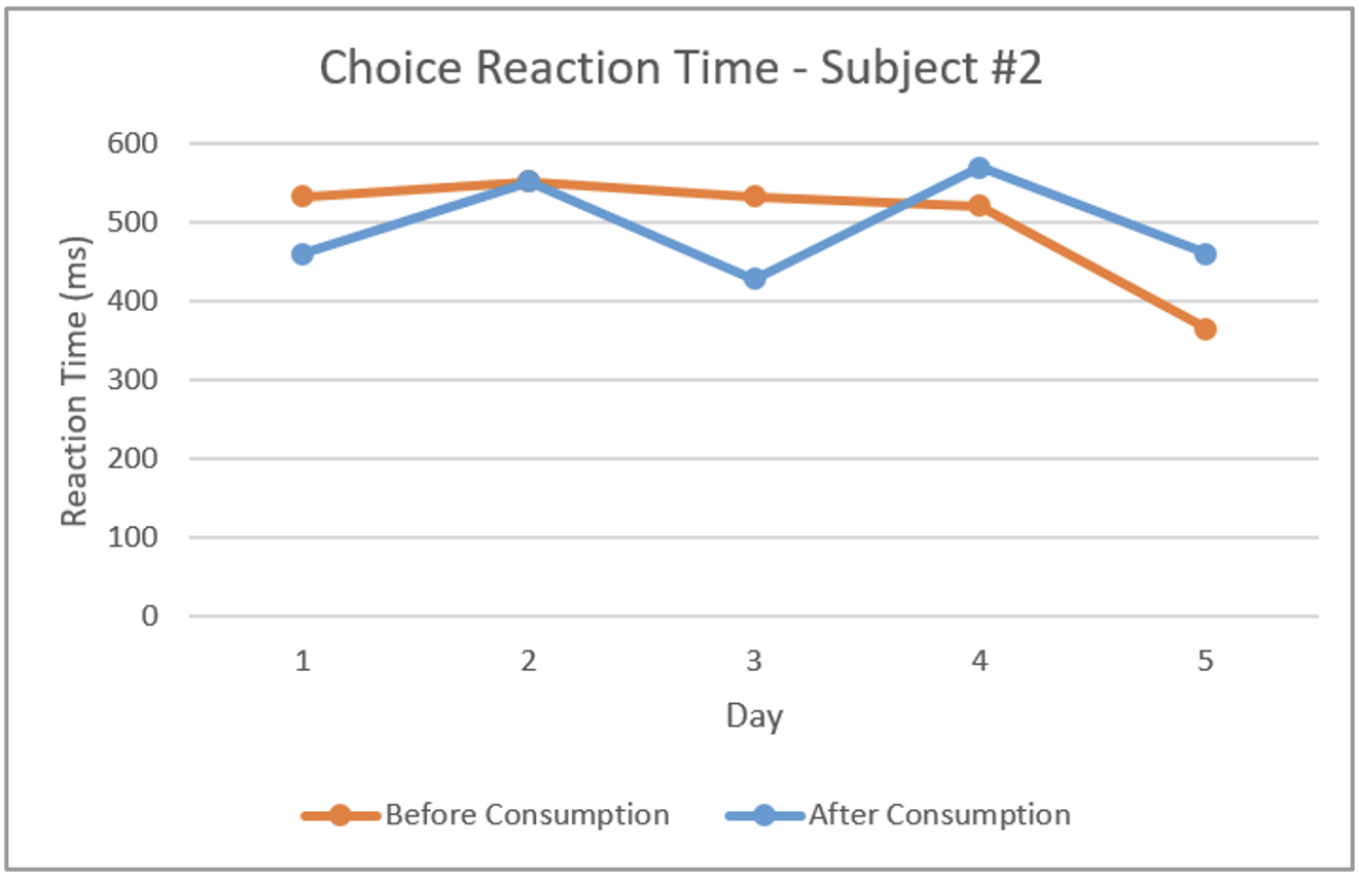

Figure 5. *Choice Reaction Time of Subject #2*

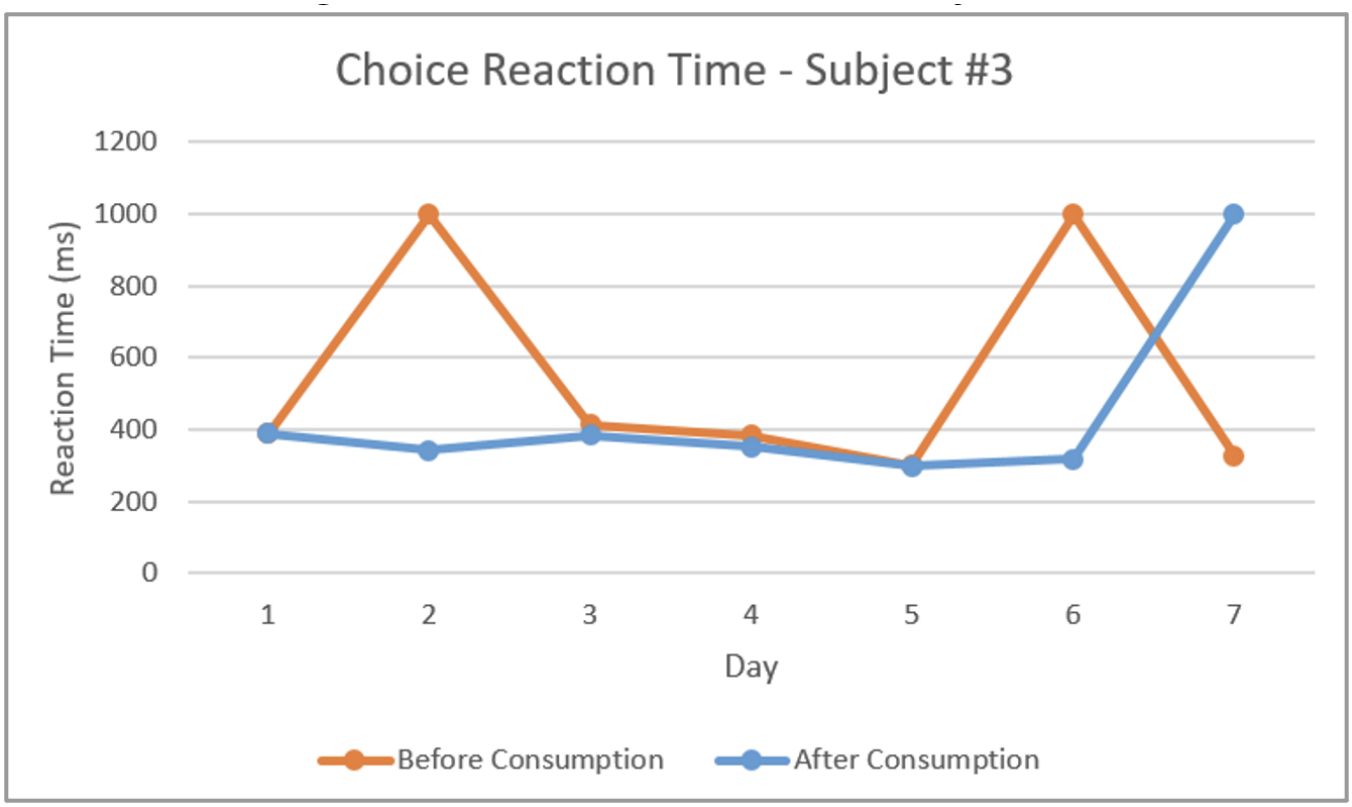

Figure 6. *Choice Reaction Time of Subject #3*

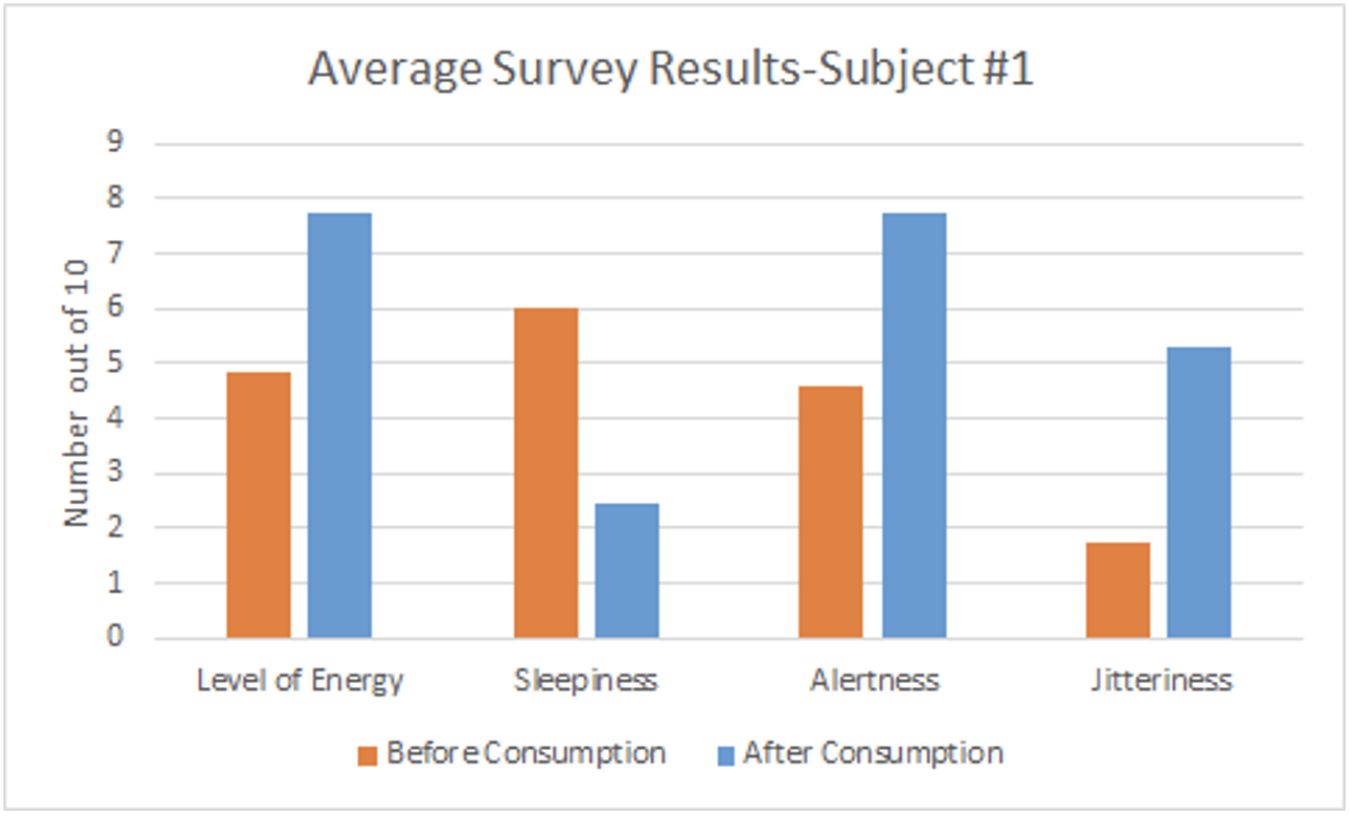

Figure 7. *Average Survey Results of Subject #1*

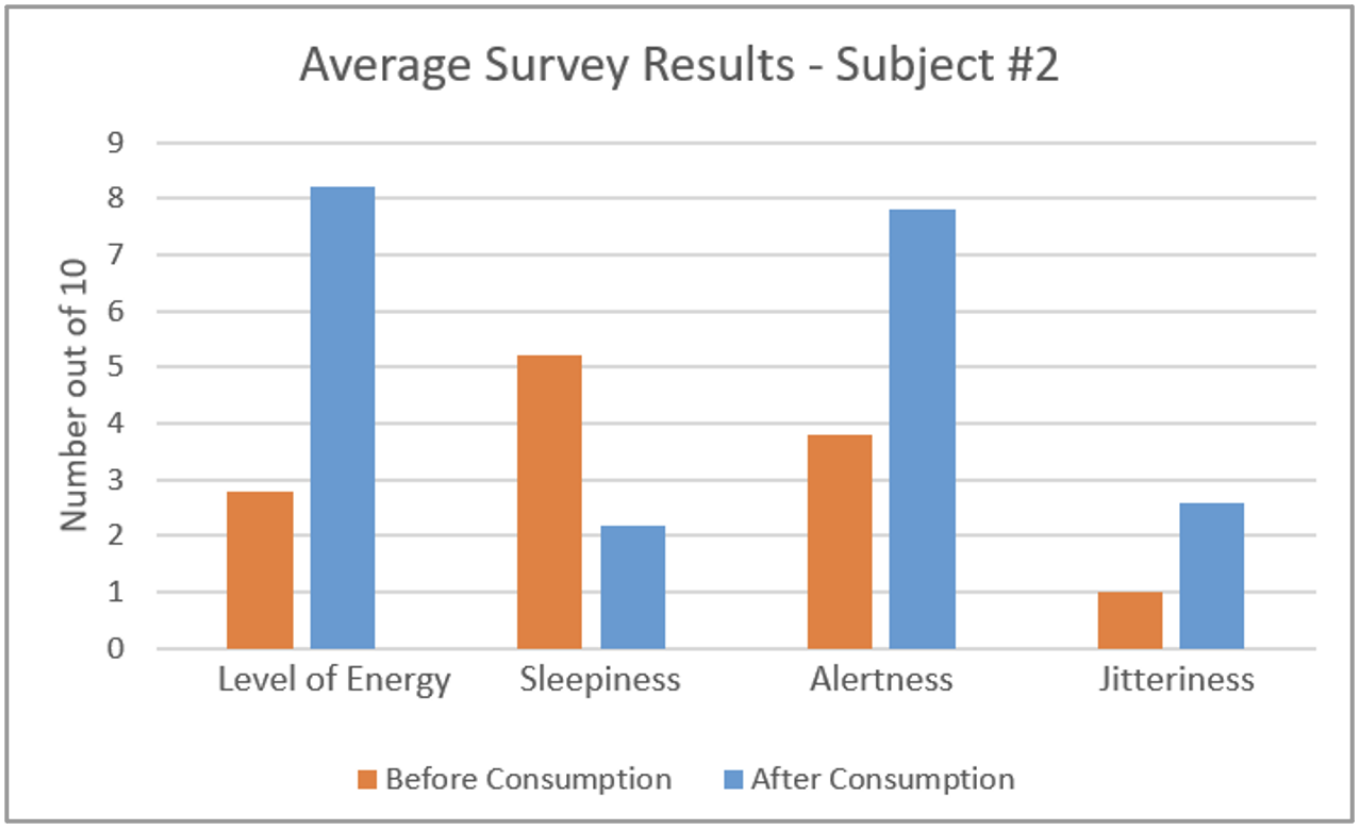

Figure 8. *Average Survey Results of Subject #2*

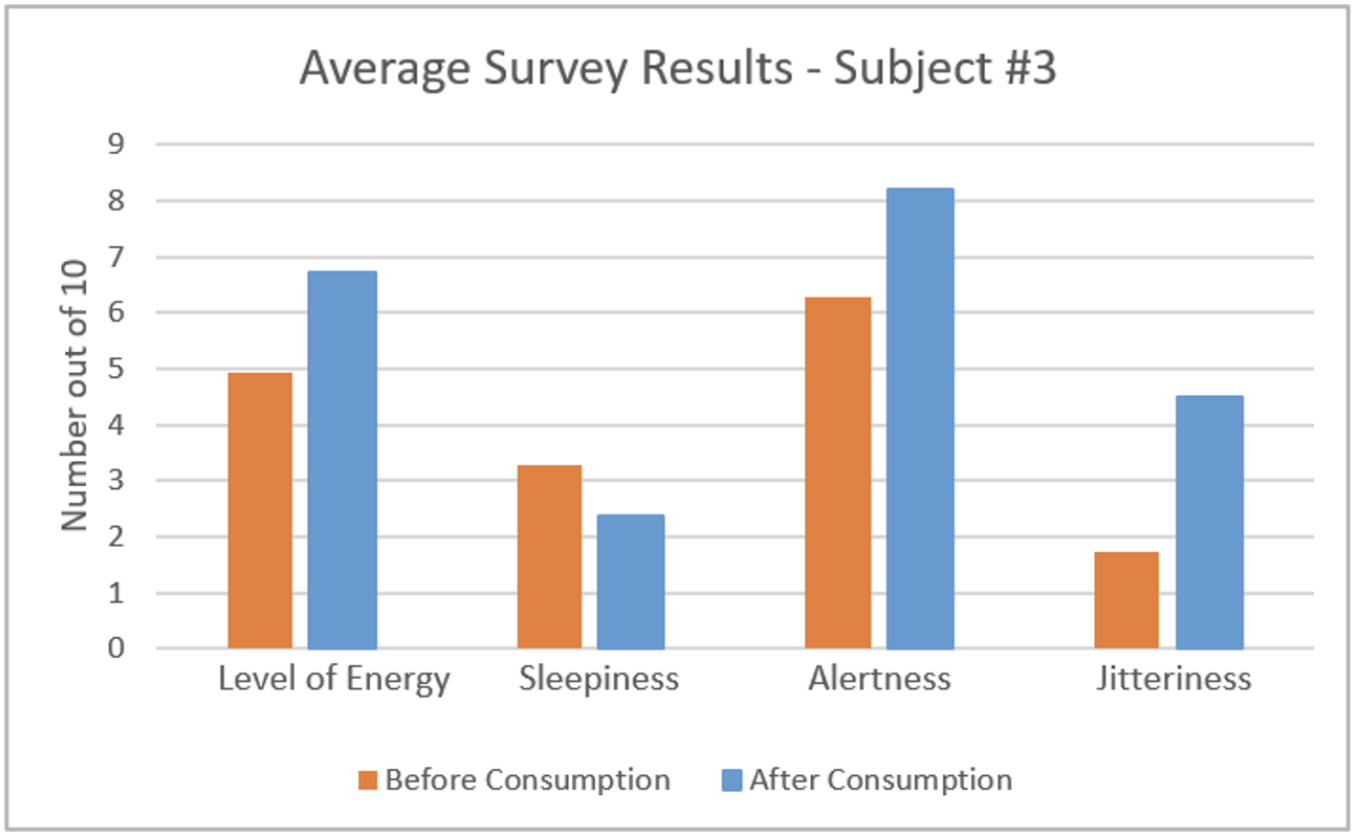

Figure 9. *Average Survey Results of Subject #3*

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