Cell phone restriction correlates with increased systolic blood pressure and GSR but not heart rate

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Keypoints:

- Previous studies have reported feelings of anxiety amongst cell phone users when separated from their device.
- Slight increase in blood pressure is seen in subjects who are separated from their cell phones.
- Increased blood pressure may be indicative of an increased stress response.

Abstract

Method and design: This is a blinded-study comprising of 22 undergraduate students (11 male, 11 female) of the University of Wisconsin Madison whose average ages range from 21.27 to 22.63. Subjects were divided into experimental groups and control groups. Both groups were assigned a series of puzzles, and without revealing the purpose of the study we separated cell phones from experimental groups while allowing the control group to keep their phones. Heart rate, blood pressure, and GSR values were taken at the time intervals of 0, 15, 30 and 45 minutes. We took means of all values for each time point, and performed t-tests to assess whether the values were statistically different at each time point.

Result and conclusion: Mean systolic blood pressure in the experimental group rose slightly across the test period, while the same measure in the control group actually decreased slightly. Heart rate measures in both groups did not increase over the course of the test period. GSR values in the experimental group rose slightly over the course of the test period, while the control GSR values remained relatively the same. These results only provide modest evidence to support the idea that separation from the cell phone induces the onset of the acute stress response.

Introduction

According to the Nielsen 2010 Media Industry Fact Sheet there are over 223 million cell phone users in the United States, of which approximately 18 percent use smartphones[1]. This number has risen since 1990, in which there were approximately 6 million cell phone users in the United States[2]. While some feel this technological advancement signifies human progress, others may argue that such technology may confer a physiological cost[3,4, 5].

It is very possible that the rate of cell phone use has become so high that individuals may develop varying degrees of psychological attachment to their cell phone devices[3, 4, 5]. Researchers in the UK claim to have reported feelings of panic and anxiety amongst cell phone users during periods in which they were separated from their device[3]. A Swedish prospective cohort study in 2011 showed there were cross-sectional associations between high compared to low mobile phone use and stress, sleep disturbances, and symptoms of depression[4]; however, the results were based on questionnaires of mostly qualitative variables. Nonetheless, these findings both provide evidence for the emotional investment people attach to their cell phone, and the onset of stress when separated from the device, despite the lack of physiological confirmation.

Another study attempted to analyze neurological and cardiovascular variables, in addition to state anxiety questionnaires, to evaluate the physiological and psychological response to cell phone, email, and social networking restriction[5]. This study was done over a week long period, and no significant correlation was found between social technology restriction and altered autonomic nervous system activity, despite a correlation with increased state anxiety. However, this specific study seems to measure a more long-term effect of separation from one’s cell phone, rather than the acute response to separation.

In an acute response to stress, the hormones adrenaline and cortisol are released, and the sympathetic nervous system is activated, increasing heartbeat, breathing rate, perspiration, and constricting blood vessels to get more oxygen in the blood, and more blood to the core of the body instead of the extremities[6]. Constriction of blood vessels and increased heart rate results in raised blood pressure, but only temporarily; when the stress reaction goes away, blood pressure returns to its pre-stress level. This is considered situational stress, and the effects are generally short-lived and disappear when the stressful event is over[7]. Therefore, it is possible in previous studies that the stressful event was immediate, and the subsequent measurements only analyzed variables that had returned to baseline values.

We will test that hypothesis that in response to the situational stressor of separation from one’s cell phone device, subjects should demonstrate signs of the acute stress response. It is expected that this result would be more pronounced amongst subjects demonstrating high cell phone use, and likewise should be minimal or absent in subjects showing low cell phone use. Three physiological measurements were analyzed to measure for signs of the acute stress response: blood pressure, using a manual sphygmomanometer; heart rate, using a pulse oximeter; and Galvanic Skin Response (GSR), to assess changes in skin surface perspiration.

Materials and Methods

Subjects were divided into two groups, a control and experimental group. The control group was composed of individuals who were allowed to have their cell phones when they were given puzzle packets, which consisted of a crossword puzzle, a word search and a Sudoku puzzle. The experimental group was not allowed to have their cell phones while completing the puzzles. Before starting the experiment we obtained signed-written consent forms from all 22 subjects who participated in the experiment, which met the intended purpose of outlining our experiment and ensured the participants agreed to the conditions of our study. This consent form did not reveal the purpose of our experiment, which ensured the experiment remained blinded, and promised subjects a reward for completion of the puzzle packet. The purpose of the puzzles was to create a situation in which the subject was separated from their cell phone without revealing the motive of the experiment.

In order to determine the relationship between stress level and separation from the cell phone, we took three initial measurements while subjects still had access to their device: blood pressure, using a sphygmomanometer along with a stethoscope; heart rate, using a pulse oximeter; and Galvanic Skin Response (GSR), to measure the change in skin surface perspiration using the BioPac Systems interface. After the initial measurements, we took away the experimental group's cell phones and stowed them in a box to be monitored by the experimenters. The control subjects were allowed to have their cell phone throughout the duration of the experiment.

Puzzle packets were given out to all participants, which they were told to work on for about an hour. A specific time frame for the experiment was not given so the subjects would not know when the last measurements would be taken. This prevented subjects from changing their behavior in response to the knowledge that the experiment would be ending soon. We monitored the groups to make sure both were only focusing on the puzzles and placed them in the back room to not be distracted. In addition to the initial 0-minute mark, we took the same three measurements 15, 30, and 45 minutes into the experiment. Following the last measurement, we gave the subjects a survey regarding their cell phone usage to compare with the other test subjects and try to correlate our results. Their cell phones were then returned and rewards were given out based on participants' level of completion of the puzzles.

With the data that was collected, t-tests were run in order to analyze the data. The t-test gave values to compare group averages of the variables measured (the blood pressure, heart rate, and GSR). The post experiment surveys were also analyzed. Subjects were asked to rank the main functions of their phone on a number scale from one to five, one being the most important. These rankings were then grouped and organized to compare how the experimental and control groups valued the use of their phones. The average amount of time spent on the participants' phones for the functions of texting, phone calls, and having their phone with them was found for both experimental and control groups to compare as well.

Results

The collected data was organized in Microsoft Excel spreadsheets and grouped according to experimental or control groups for each of the three measurements of heart rate, blood pressure and Galvanic Skin Response. T-tests between the experimental and control groups were conducted at each of the four time points for the three measurements. The results of the t-tests were compiled into tables and converted into graphs, which depicted the relationship between the test measurement and the corresponding time point.

Heart rate data, compiled in Figure 1, comparing the experimental and control groups revealed an average initial heart rate of 72.1812 beats and 70 beats per minute for the experimental and control groups, respectively, with a starting p-value of 0.2498. Both groups experienced a decrease in heart rate at the 15-minute time point, though following this second data collection time, the experimental group's heart rate increased back to their average initial heart rate. The control group continued to experience a drop in heart rate through the 30-minute time point, though their average heart rate began to increase back toward their starting rate at the end of the experiment. The p-value at the 45-minute time point was 0.0903.

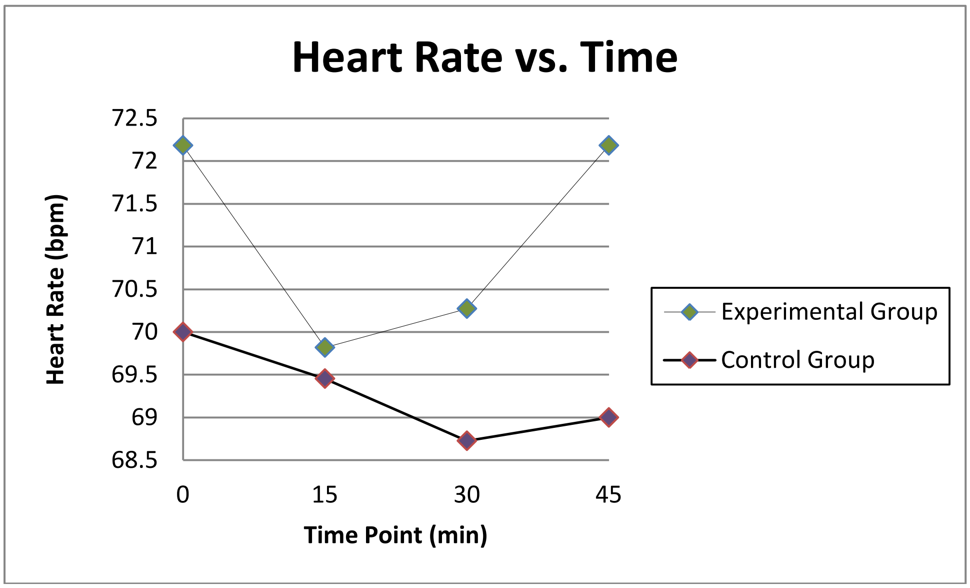

Figure 1. The relationship between heart rate, measured in beats per minute, and time, measured in minutes, for both the experimental (n=11) and control groups (n=11) can be seen here. P-values for the experimental and control groups were 0.2498 at the zero minute mark, 0.4589 at fifteen minutes, 0.2816 at thirty minutes and 0.0903 at forty-five minutes.

Measurements of blood pressure, as can be seen in Figures 2 and 3, were broken down into the systolic beating and diastolic resting components, respectively. Systolic blood pressure for the experimental group measured an initial average of 111.3636 mmHg, while the control group measured an average of 111.8182 mmHg. The beginning p-value was 0.4541. Graphically, the second and third time points illustrated an early increase in the experimental group and decrease in the control group's systolic measurements. At the 45-minute mark, the experimental group's average systolic blood pressure increased to 116.3636 mmHg, while the control group saw a decrease to 109.0909 mmHg, with a p-value of 0.0760.

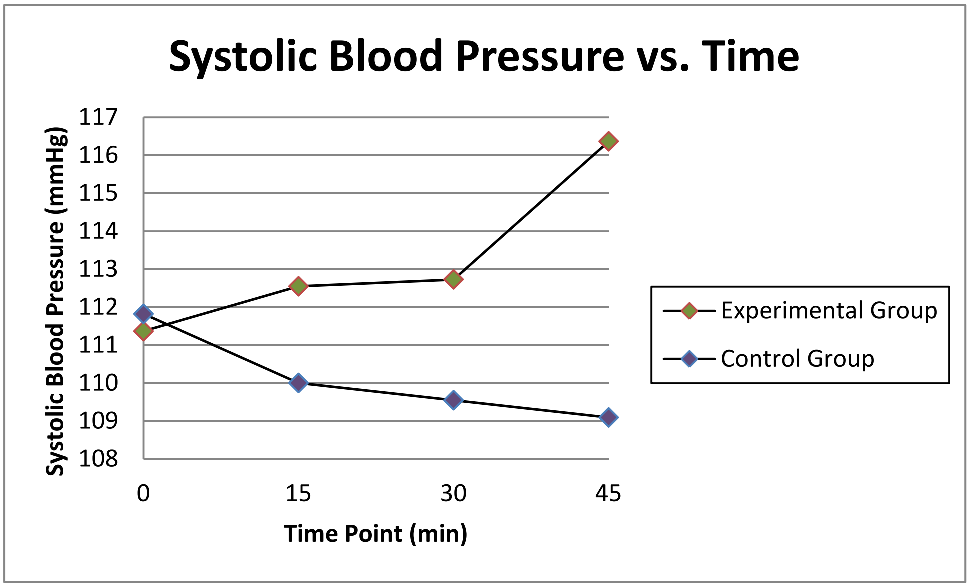

Figure 2. This depicts the relationship between systolic blood pressure, measured in mmHg, and time, measured in minutes, for both the experimental (n=11) and control (n=11) groups. P-values for the experimental and control groups were 0.4541 at zero minutes, 0.2707 at fifteen minutes, 0.2562 at thirty minutes and 0.0760 at forty-five minutes.

Diastolic blood pressure levels began at 63.6363 mmHg for the experimental group and 63.1818 mmHg for the control group, with a p-value of 0.4588. On average, as time passed the experimental group experienced a slight decrease in diastolic blood pressure through the 30-minute time point and a final increase at the 45-minute mark to 65.9090 mmHg. The control group's levels decreased after an initial unwavering average in diastolic blood pressure, but began to advance back toward the starting point with an ending value of 62.2727 mmHg. The final 45-minute time point's p-value was 0.2178.

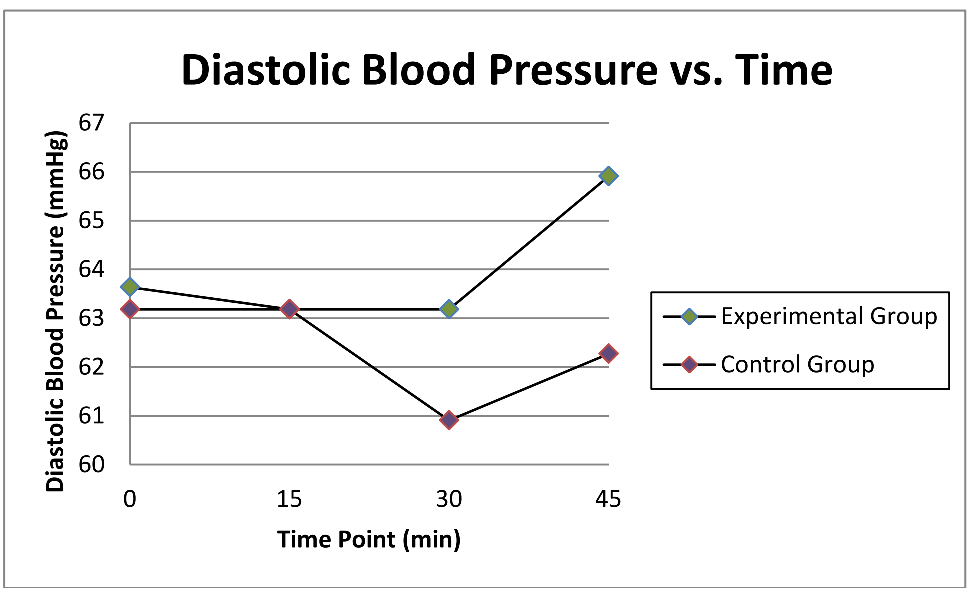

Figure 3. This illustrates the relationship between diastolic blood pressure, measured in mmHg, and time, measured in minutes, for both the experimental (n=11) and control (n=11) groups. P-values for the experimental and control groups were 0.4588 at zero minutes, 0.5000 at fifteen minutes, 0.2803 at thirty minutes and 0.2178 at forty-five minutes.

Galvanic Skin Response (GSR) testing exposed the initial average for the experimental group was -0.0675 and a beginning average of -0.0335 for the control group, with a p-value of 0.101. Referring to Figure 4, the control group, along with the experimental group, experienced a rise in the GSR values through the third time point at 30 minutes. After this point, the experimental group's average value continued to increase to -0.0299, while the control group's value decreased to -0.0321. The final p-value was 0.3940.

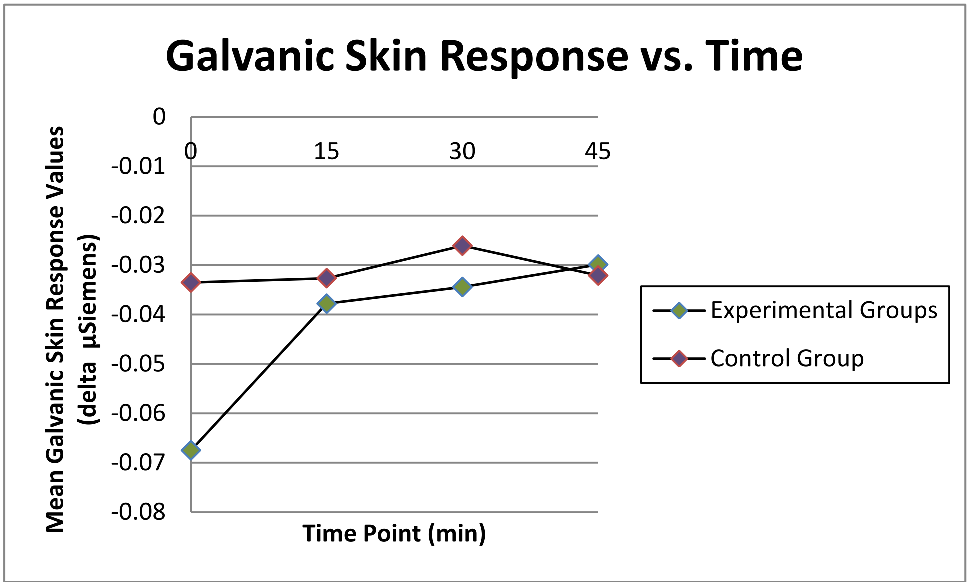

Figure 4. The relationship between Galvanic Skin Response, measured in delta µSiemens, and time, measured in minutes, for both the experimental (n=11) and control (n=11) groups is depicted here. P-values for the experimental and control groups were 0.1006 at zero minutes, 0.0.2823 at fifteen minutes, 0.2738 at thirty minutes and 0.3941 at forty-five minutes.

Mean Arterial Blood Pressure (MABP) data, represented in Figure 5, compared the experimental and control groups and showed an average initial MABP of 79.5454 mmHg and 79.3838 mmHg for the experimental and control groups, respectively. The experimental group experienced a gradual increase in MABP through the first three time points with a greater increase at the last time point. The control group underwent a drop in the average MABP for the first three time points but experienced an increase in MABP toward the direction of the initial value at the final time point. Final values of MABP were 82.7271 mmHg and 77.8786 mmHg for experimental and control groups, respectively. The correlation between the experimental and control groups was 0.0685.

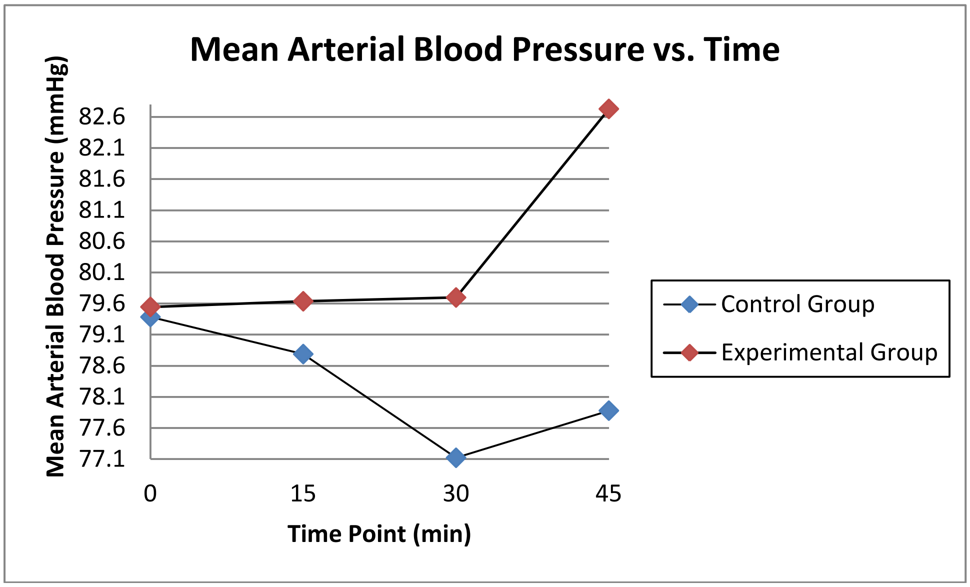

Figure 5. The relationship between Mean Arterial Blood Pressure, measured in mmHg, and time, measured in minutes, is shown here for both the experimental (n=11) and control (n=11) groups. The p-value for the experimental and control groups was 0.0685.

Figure 6 shows two individuals, one from the control group and one from the experimental group, whose data fit with the results expected based on the hypothesis. The experimental individual began with a MABP of 81.6666 mmHg, a value which steadily increased to 96.6665 mmHg at the final time point. The control individual experienced a different trend in which the MABP began at 81.6665 mmHg, underwent a small increase to 83.3332 mmHg and finally decreased below the initial value to 79.9999 mmHg during the final two time points. The correlation between the experimental and control individuals was 0.0528.

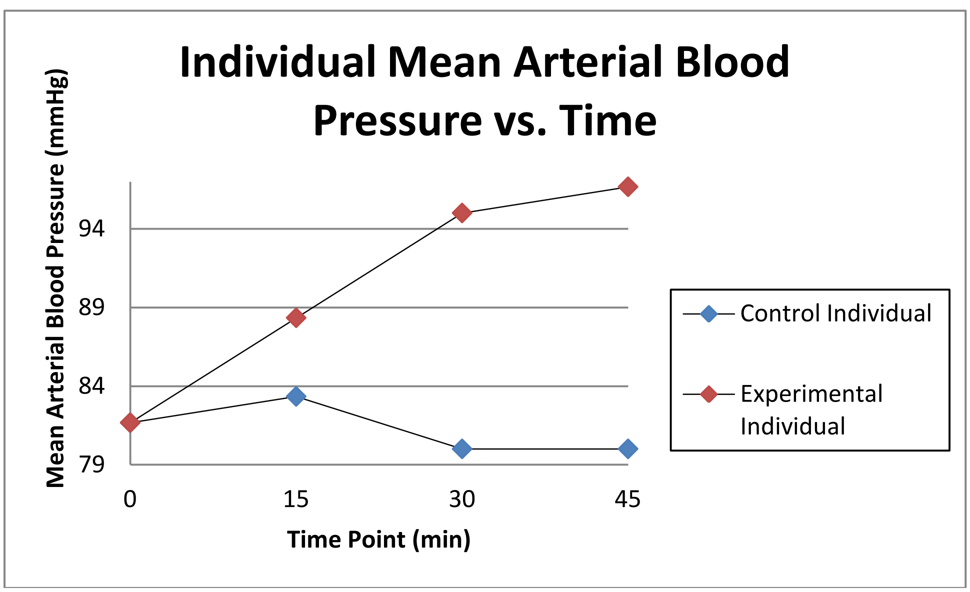

Figure 6. The graph shows the relationship between Mean Arterial Blood Pressure, measured in mmHg, and time, measured in minutes for the control and experimental individuals who best supported our hypothesis. The p-value between the experimental and control individuals was 0.0528.

Discussion

The extremely rapid expansion of cell phone use in the United States over the past 20 years[1,2], in conjunction with the increasing reports of adverse psychophysical consequences resulting from separation with the cell phone device[3,4], warrants further inquiry into the health effects of cell phone use. While a previous group already examined neurological, cardiovascular and state anxiety variables over a week long period of cell phone restriction[5], this study only accounted for a long term effect of separation from the cell phone. Experimental subjects from the cell phone restriction group demonstrated altered state anxiety levels, but cardiovascular and neurological variables showed no significant difference across the study period[5]. However, it is possible that the physiological variables measured had become desensitized after the initial separation event, and therefore went undetected by a week-long analysis.

Since then, it has been postulated that rather than causing a chronic change in autonomic variables, perhaps separation from the cell phone elicits a more immediate response, consistent with the situational stress response[7]. Therefore, this study measured heart rate, blood pressure, and GSR during the first 45 minutes after separation from the cell phone, and compared these values to a control group which was allowed to retain their cell phone devices during the test period.

Overall, the results collected during the study show modest evidence for the onset of the acute stress response in conjunction with separation from the cell phone. The main measure consistent with our original prediction came from the blood pressure results. While the mean systolic pressure for the control group showed a minor decrease across the test period (4 mmHg), the mean systolic pressure for the experimental group showed a slight rise of approximately 5 mmHg. This corroborates the prediction that the blood pressure for the experimental group would increase throughout the test, compared to the control. Diastolic blood pressures show less significant changes throughout the test period, and despite the apparent increase in experimental mean diastolic pressures from the 0 to 45 minute time points, the mean diastolic pressure fluctuates around its initial value of 64 mmHg. Referring to mean arterial blood pressure, it is uncertain whether the experimental group data indicates an actual increase in mean arterial pressure, seeing as the only the 45 minute time point shows a modest increase (3 mmHg) in pressure, while the 0, 15, and 30 minute time points reveal virtually equal pressures. However, referring to the individual data, the particular subject revealed a steady increase in mean arterial blood pressure throughout all of the data points, while the matched control showed a relatively constant mean arterial pressure over time. Therefore, it is a meek possibility that mean arterial blood pressure data corroborates the acute stress hypothesis of cell phone restriction leading to increased blood pressure.

The mean heart rate measures for both the control and experimental groups show meager changes across the entire test period, only varying a few beats per minute from the baseline measurement. Furthermore, the mean heart rate measures of the experimental group drop during the 15 and 30 minute time points, before rising back to a value near baseline at the 45 minute mark. This phenomenon may be a result of the subject’s pulse being elevated at the beginning of the experimental period due to the distractions of being introduced to a novel situation. Our original prediction that the heart rate would increase in the phone-restricted group was, therefore, not confirmed.

The GSR measures seem to provide unclear results. Negative measures obtained on the GSR were unavoidable, despite repeated attempts to solve the issue. It is unclear how a negative conductance would be obtained, and as a result relative changes in the GSR values from baseline were used to assess changes in skin surface perspiration. Accordingly, the experimental group's average GSR value showed a slight increase, whereas the control group's mean GSR value remained relatively constant throughout the test period. The relative increase in mean GSR value for the experimental group would seem to be consistent with the acute onset of the stress response; however, the negative GSR values may conflate this evidence.

Evidence for onset of the acute stress response in the experimental group was not consistently seen across all three of the measured variables, reducing the validity of the acute stress hypothesis for subjects separated from their cell phone. However, the presence of slightly increased blood pressure and skin conductance in the experimental group as compared to the control still stands as results. Along with the previous studies that have demonstrated evidence of psychophysical effects in conjunction with separation from the cell phone[3,4,5], these results also warrant further investigation into the matter of humans' attachment to cell phones and other social media modalities. Evidence has clearly demonstrated that humans exhibit anxiety when separated from the cell phone device[5], however evidence for a physiological manifestation of this anxiety is unclear. This study provides modest evidence for physiological evidence of stress; however, the results are not strong enough to indicate certainty. This could result from the small sample size or limited diversity in the subjects, and therefore a larger scale study would be necessary to truly evaluate the physical effects of cell phone separation on the general population. Furthermore, it may not be possible to obtain evidence of the physical manifestation of anxiety using solely non-invasive methods. For example, analysis of cortisol levels collected at each time point would give an easily quantifiable correlation between perceived anxiety and the physical response. Unfortunately, this adds entirely new confounds in relation to the ethics of performing experiments on student volunteers.

Inquiry into how the psychological experience of anxiety[5], occurring in conjunction with separation from one's cell phone, affects the body would be a valid topic for further research. The possibility cannot be ruled out that the instantaneous experience of anxiety may not have an easily measureable physical manifestation in the acute situation that can be measured non-invasively. Additionally, as cell phones continue to evolve and provide more applications, it could be important to see how much total time the average person spends on their cell phone, and track how that statistic has changed over time. As the population continues to grow and use mobile phones, it is important to understand the full impact of the use of such devices.

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Author Contributions

1. Conception and design of the experiments: Matt Solverson came up with the idea of the experiment and the rest of the group came up with the design of it and how to perform all of tests and data collection.

2. Collection, analysis and interpretation of data: Eric Christenson and Matt Solverson were in charge of running the tests (blood pressure, heart rate, and GSR) on the subjects. Laine Ferrara and Jamie Kim gathered participants and organized the time intervals when they were supposed to be tested. They also collected and organized the data that was reported by Eric and Matt. The all of us worked on interpretation the data and results.

3. Drafting the article or revising it: While constructing the paper, work was divided out to ensure work was even and would be completed on time. Eric was in charge of the materials and methods section, along with working on the references and author contributions. Laine was in charge of creating the data tables and writing the results. Jamie worked on the abstract and key points. The introduction and discussion was written by Matt. Once everything was written, it was revised as a group to make any final corrections.

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