Effects of time constraints and unfamiliar test conditions on physiological stress responses

Lab 603, Group 10
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Abstract

Many people experience varying levels of stress throughout their lifetime. There are numerous circumstances that can be identified as stressors, and it is known that stress can cause measurable physiological responses. For some, taking tests induces stress. This study investigates whether testing under time constraints and unfamiliar test content elicit physiological stress responses. Subjects were asked to complete three tests. Each test manipulated one of two variables, time constraints and expected level of familiarity with test content. Blood pressure, heart rate and grip force served as the physiological stress responses that were measured. All three factors were measured before and after each test was administered. Results demonstrated that generally, all three tests induced a change in the physiological stress responses when compared to subjects' baseline measurements. Contrary to our hypotheses, however, there was not a significant increase in physiological stress responses when exposed to time constraints and/or unfamiliar test content compared to the control test condition. While we did observe some general trends, most findings were not significant. However, subjects did experience a significant decrease in grip force when both time constraints and unfamiliar test content were considered. Due to the significant changes in stress responses observed from baseline after performance of each test and the lack of significant changes between the three different tests administered, we suggest that the idea of taking a test itself is what elicited physiological stress responses and not necessarily time constraints or unfamiliarity with the test content.

Introduction

The primitive environment in which animals previously lived in resulted in the development of physiological responses that allows the ability to detect and respond to external stressors. For example, the threat of being eaten by any large carnivore requires quick mobilization of energy in the form of glucose. The stressful nature of the situation induces a physiological response of the sympathetic nervous system which leads to an increase in heart rate, breathing rate, and blood pressure to ensure rapid transport of the essential nutrients and glucose to the muscle cells (Jansen 1995; Sapolsky 2011). Varying degrees of stress trigger different levels of these physiological responses, which also often differ among individuals (Gunnar, 2006). Although humans no longer face these primitive dangers and our definition of stress has changed over the centuries, when humans feel stress, the same bodily reactions are activated and produce similar effects. Living in a fast-paced society has introduced novel types of stress, specifically from social stressors, where it can be challenging to find a balance between work, school and personal life (Blanchard, 2001).

Time Constraints

Oftentimes, the cause of stress can be a time-related pressure. It has been found that when faced with time constraints there is an increase in physiological and psychological reactions (Walen, 2002). In a study performed by Wahlstrom, et al (2002) participants were subjected to a time pressure and a verbal provocation task while working with a computer mouse. It was found that there was an increase in muscle activity, heart rate, and blood pressure when performing this activity under the time

constraint (Wahlstrom, 2002). In addition, internal decision-making under stressful situations varies among individuals (Ozel, 2001). Even given the same set of information, people may interpret it differently depending on their individual degree of stress and the amount of time pressure that they experience. Such a result is also shown by Young et al (2012), where participants under a time pressure spent less time evaluating gambles than those who had no time pressures, suggesting that possible stress due to time constraints may have an altering effect on making accurate decisions.

Unfamiliarity of Test

Facing an unfamiliar task may also serve as a potential stressor. It has been shown that when given preparatory information on a task, there is less stress experienced (Inzana, 1996). Although this information was collected by having subjects report their level of stress, we can assume that with higher levels of stress reported came an increase in physiological responses to stress as well. However, the physiological stress responses such as heart rate, blood pressure, and muscle activity require further investigation to verify this claim. In a separate study, Renaud and Blondin (1997) required participants to perform the Stroop task, a test in which subjects are presented with a word that spells a color, but appears in a color different than the color indicated in the spelling. They are then asked to state either the word or the color. When this was tested before another color-related task, heart rate was more likely to increase. The experimenters thought this was due to the subjects being less prepared for and less familiar with the color-interference task.

Familiarity of a task also has to do with how comfortable you feel with the material. Situations that test concepts that individuals are less exposed to tend to induce different levels of anxiety and stress among individuals. For instance, Faust et al (1992) reported similar increased physiological responses in subjects with high math anxiety as the difficulty of mathematical tests performed increased. In a different but related study, Plessow et al (2012) examined forty-eight individuals' responses to a standardized Trier Social Stress Test, a laboratory procedure used to reliably induce stress in research participants. Following the test, they were exposed to a different, yet similarly stressful test. Findings suggested that these stress-related tests increased sympathetic nervous response, which is characterized by a higher blood pressure and heart rate. However, Koolhaas et al (2011) presented a contradictory hypothesis. They noted that physiological responses can be self-initiated due to anticipation of performing a certain task. When completing unpredictable or unfamiliar tasks, they found that there was an absence of this anticipatory response. Therefore, individuals may actually display an increase in physiological responses when they are aware that the material they will be tested on is going to be challenging. On the other hand, individuals may not experience as much stress when they are not aware of the complexity or content of the test. More research needs to be done to parse through these alternative conclusions.

Objective of study

While the physiological stress effects of time constraints and unfamiliar test conditions have been investigated in separate contexts, there has been a minimal amount of research in regards to the combined effects of these two factors. For this

reason, our study will investigate the physiological responses due to time constraints and unfamiliar test concepts, as well as their combined effects. In addition, we hope to investigate whether or not grip force changes due to induced physiological stress. There has been previous studies indicating heart rate and pulse changes in response to stressors, yet little research has investigated grip force as a physiological measurement in relation to the purpose of our study. Ultimately, we hope to uncover information that will be valuable for academic testing purposes. For the purpose of this study, a physiological stress response will be indicated by a significant change in blood pressure, heart rate, and grip force.

Hypotheses

H1) Do time constraints create increased physiological stress responses measured according to an increase in blood pressure, heart rate, and grip force?

H2) Does the unfamiliarity of a test create increased physiological stress responses measured according to an increase in blood pressure, heart rate, and grip force?

H3) Does the combination of time constraints and unfamiliarity of a test create an even larger increase in physiological stress responses measured according to blood pressure, heart rate, and grip force?

Predictions

We predict that the timed, familiar condition will demonstrate increased stress levels indicated by a significant change in the heart rate, blood pressure, and grip force compared to the stress responses from the untimed, familiar control condition. This

would suggest that time pressures affect stress responses. We believe this to be true because the time constraints may cause an individual to feel flustered, pressured, and stressed when performing the test. In line with these predictions, we foresee that the timed, unfamiliar testing condition will induce a greater amount of stress responses than the timed, familiar testing condition, suggesting that the unfamiliarity of a test has an effect on physiological responses. We think this may occur because people are generally more stressed when presented with unfamiliar situations. Lastly, we predict that the timed, unfamiliar testing condition will cause the greatest amount of stress and demonstrate the greatest change in the measured physiological responses when compared to the untimed, familiar control condition. This would suggest that the combination of time constraints and unfamiliar concepts has the greatest effect on stress responses. We think that by applying both testing conditions simultaneously, greater anxiety will occur among test takers.

Materials and Methods

Subjects were recruited from the Physiology 435 Lab 603 (n=20; 7 Male, 13 Female; average age: 22). Each subject was instructed to participate in four different conditional measurements: baseline, untimed/familiar, timed/familiar, and timed/unfamiliar. There were two sets of controls. The baseline measurement acted as a control for the effects of testing in general. The untimed/familiar was the control group when observing the effects of the different conditions.

Throughout the experiment the following measurements were obtained: heart rate, blood pressure, and grip force. Heart rate was measured manually, counting

heartbeats per 30 seconds and multiplying by two to obtain beats per minute. At the same time heart rate was measured, we used the digital wrist blood pressure cuff to record the subject's blood pressure. The final baseline measurement, grip force, was measured with the hand dynameter. The hand dynameter was calibrated at -25 kg. The stronger the subject's grip force, the less negative the measured value, suggesting greater tension. The subject was prompted to grip the hand dynameter as hard as they could for six seconds. Using the BIOPAC software, we determined the average grip force the subject exerted between 30 milliseconds and five seconds. Calculating the average force during this time period maintained consistency of our measurements between subjects. This allowed us to account for slight variations in start and stop times between different individuals.

Procedure

Subjects were greeted and given a brief description of the experiment. They were then asked to read and sign our consent form and asked if they had any questions before beginning. Next, we recorded the subjects' baseline grip force followed by their baseline blood pressure and heart rate while they were seated comfortably at the test station. Subjects were then given test condition one: an untimed, familiar test. It was a ten-by-ten multiplication table that was to be completed in its entirety with no time constraint (**Figure 1**).This took approximately three minutes. Immediately following completion of the test, subjects were instructed to grip the hand dynameter in the manner described above. After grip force was measured, heart rate and blood pressure were recorded simultaneously in the manner as described above. These measurements

took approximately one minute. Our subjects took a brief break of about 30 seconds before proceeding to the next test. Next, subjects were asked to complete test condition two: a timed, familiar test (**Figure 1**). This test required subjects to try and complete the same ten-by-ten multiplication table in 60 seconds, with a verbal warning when ten seconds remained. As soon as time was finished, the three measurements were obtained in the same manner as after the first test. After subjects relaxed for around 30 seconds, they were given test condition three: a timed, unfamiliar test (**Figure 2**). This test instructed subjects to try and complete an unfamiliar deviation of the ten-by-ten multiplication table in 60 seconds, with a verbal warning when ten seconds remained. The deviation of the multiplication table required subjects to apply the formula $f(x)=(A-1)(B+1)$ to the standard table, where A is the column of numbers and B is the row of numbers. Following this test, all three measurements were recorded again in the same manner as after the previous tests. Overall, each subject's testing took approximately 11 minutes. Refer to **Figure 3** for a complete outline of procedural and time length details.

Analysis

After data collection, we calculated the average physiological responses of blood pressure, heart rate, and grip force for each testing condition. The initial baseline measurement taken at the start of the experiment was compared to the measurements derived from each testing condition using paired *t*-tests to determine any significance. Next, we computed paired *t*-tests to compare testing conditions between one another to determine whether time constraints and/or unfamiliarity of the test had a statistically

significant difference in physiological stress response measured according to blood pressure, heart rate, and grip force. The paired *t*-tests compared each of the physiological responses produced by the untimed, familiar condition with the responses produced by the timed, familiar condition to determine if the time-constraints had an effect on the physiological responses. We also did the same for comparing the responses to the timed, familiar condition with those to the timed, unfamiliar condition to determine if the unfamiliarity of the test had an effect on the physiological responses. Lastly, we repeated the paired *t*-test comparing the responses to the untimed, familiar condition with those of the timed, unfamiliar condition to determine if both the time-constraints and the unfamiliarity of the test had an effect on the physiological responses.

Results

Test condition vs. baseline

The averages of the physiological measurements of each condition are shown in **Table 1**. The overall significance trends in the physiological response averages for each condition are shown in **Figure 4** through **Figure 7**. Compared to baseline measurements, participants displayed a significant increase in systolic blood pressure after performing the untimed/familiar ($p<0.05$), timed/familiar ($p<0.05$), and timed/unfamiliar ($p<0.02$) tests (**Table 2 and Figure 4**). Diastolic blood pressure increased from the baseline measurement after performing the untimed/familiar test, but decreased after performing the other two tests (timed/familiar, timed/unfamiliar) (**Figure 5**). However, all of these differences in diastolic blood pressure were not significant

(**Table 2**). Subjects displayed a significant increase in heart rate compared to baseline after performing the untimed/familiar ($p<0.002$), timed/familiar ($p<0.001$), and timed/unfamiliar ($p<0.05$) tests (**Table 2 and Figure 6**). Lastly, compared to baseline, subjects showed a decrease in grip force; however, the decrease was only significant for the timed/unfamiliar test ($p<0.04$, **Table 2 and Figure 7**).

Effects of time constraints on physiological responses

Our results showed no significant difference in blood pressure, heart rate, and grip force responses when comparing between the untimed/familiar and timed/familiar test conditions (**Table 3**). However, in general, the averages show an increase in systolic blood pressure and a decrease in diastolic blood pressure, heart rate, and grip force (**Figures 4-7**).

Effects of unfamiliarity of test on physiological responses

Our results showed no significant difference in blood pressure, heart rate, and grip force responses when comparing between the timed/familiar and timed/unfamiliar test conditions (**Table 3**). However, in general the averages show a decrease in blood pressure, heart rate, and grip force (**Figures 4-7**).

Effects of time constraints and unfamiliarity of test on physiological responses

Our results showed no significant difference in blood pressure and heart rate, but showed a significant decrease in grip force when comparing between the untimed/familiar and timed/unfamiliar test conditions ($p<0.04$, **Table 3**). In general, the

averages show an increase in systolic blood pressure and a decrease in diastolic blood pressure, heart rate, and grip force (**Figures 4-7**).

Ultimately, by comparing results to the baseline control group, as well as between the testing conditions, this enabled us to conclude that, while testing itself increased stress responses, timing and familiarity (independently or combined) did not account for that effect.

Discussion

Results showed that the tests did induce a deviation from the subjects' baseline physiological stress measurements as evidenced by changes in blood pressure, heart rate and grip force following each of the three testing conditions. This indicates that our tests did induce physiological stress compared to the control. Due to the significant increase from baseline in systolic blood pressure and heart rate elicited after both the timed, familiar test and the testing conditions that followed, the changes noted above cannot necessarily be attributed to the time constraints and the subjects' unfamiliarity with the test. The change that occurred in both conditions indicates that we cannot separate what condition is causing the result. Instead, this phenomenon can likely be attributed to the assumption that individuals experience stress based on the general idea of test-taking.

Comparison between the untimed, familiar and timed, familiar conditions does not support hypothesis one. Despite a general increase in systolic blood pressure in the timed, familiar condition, the increase was not significant. In addition, diastolic blood

pressure, heart rate, and grip force measurements remained virtually constant between the untimed and timed, familiar conditions. Though not what we predicted, these results suggest that time constraints did not have a clear effect on the measured physiological responses.

Comparison between the timed, familiar and timed, unfamiliar conditions does not support hypothesis two. Despite a general decrease in grip force in the timed, unfamiliar condition, the decrease was not significant. In addition, blood pressure and heart rate remained virtually constant between the timed, familiar and unfamiliar conditions. Though not what we predicted, these results suggest that the degree of unfamiliarity of a test does not significantly influence the measured physiological responses. This finding aligns with the Koolhaas et al (2011) study, indicating that unfamiliar conditions may not cause a measurable change in physiological response due to an unawareness of what to expect.

Comparison between the untimed, familiar and timed, unfamiliar conditions does not support hypothesis three. There was a general increase in systolic blood pressure and a decrease in diastolic blood pressure and heart rate. Most notably, there was a significant decrease in grip force in the timed, unfamiliar condition from the untimed, familiar control condition. These results suggest that both time constraints and the degree of unfamiliarity of a test may affect physiological stress responses, though not necessarily in an increasing direction as we had predicted. Also, we did not observe the greatest change in heart rate and blood pressure as we had predicted when both time constraints and unfamiliarity conditions were combined. The significant decrease in grip force, which conflicts with our hypothesis, may be explained by the idea that subjects

are exerting a larger focus on the mental task presented in the test as compared to the energy exerted while measuring grip force. In other words, the psychological/physiological effects, that time constraints and unfamiliar concepts create, may actually cause weaker physical force exertion.

In conclusion, through our tests, we demonstrated that timing and familiarity did not have an effect on physiological stress responses independent of the effect of test-taking in general. Though the data were not significant with respect to the effects of particular types of testing conditions, the fact that there were no significant effects is a reasonable result, indicating that changing timing and/or familiarity conditions alone did not affect stress responses.

Limitations

While our study found that stress was induced while completing the tests, time and unfamiliarity did not seem to be what induced those stress responses. There are many confounding variables and limitations that could have contributed to this result. For example, the testing environment was not an ideal, realistic, controlled setting and did not replicate a traditional testing site. The place at which the test was administered was a noisy environment that did not allow for adequate concentration. Ideally, working in a quiet space allows one the opportunity to focus better and to become more invested in the test. Therefore, in the future, participants should be taken to a separate room to complete the tests, or all participants could complete the tests at the same time in a controlled classroom environment. In addition, in traditional academic settings, students are able to seek clarification in order to ensure they understand the test. Because the

experimenters did not directly inform subjects that they could ask clarifying questions, subjects may have felt less inclined to ask for help even when they needed assistance. This could have potentially elicited stress that is not attributed to the experimental manipulations. Similarly, those that did speak up and ask questions may have had an advantage to feel more comfortable while taking the tests. In the future, we could include a sentence in the instructions for each test inviting participants to ask questions if needed. Experimenters were also present while subjects were tested. This may have caused some subjects to feel self-conscious about completing a simple multiplication table that college students are commonly expected to know how to complete. Therefore, it is possible that what was believed to be stress induced by the tests, was actually stress produced as a result of being watched and feeling judged by one's peers. This could be eliminated through changing the testing environment as described above. In addition, experimenters could exit the room while the tests are being taken to further control for this effect.

Our study also failed to utilize a pre-test survey in order to determine whether or not certain individuals had predisposing qualities that should have been considered. For example, it may have been useful to determine if subjects self-identified as good test-takers, or if they consider math an area of strength. These factors may have played a role in the amount of stress that subjects experienced, which would then trigger varying physiological stress responses.

The timed, unfamiliar test was designed to be difficult; however, it may have been that the test was too hard or that the subjects did not understand the instructions. It was observed that subjects spent a significant portion of the time allotted to complete

the test making sense of the directions. It was also observed that many subjects lacked motivation to complete the test. This may be attributable to the fact that they were aware that there were no rewards or consequences for their performance, such as a grade in a class. When given the ten second warning, some students stopped taking the test altogether. Similarly, subjects' body language seemed to indicate a decreased will to complete the test. This may have changed the measure of physiological stress responses. To fix this, we would administer a slightly easier task, yet one that would still be unfamiliar to the population being tested. We would also administer a test that would be more similar to a course exam, allowing us to draw more relevant conclusions. Lastly, subjects were students from Physiology 435 who were primed to the testing environment and circumstances. There exists the possibility that other subjects shared the aspects of our study with future participants. In the future, it would be beneficial to find participants that have no prior knowledge of our classroom project.

To come to more robust conclusions, we could have manipulated the experiment in the following ways. First, we could have increased the number of participants, which may increase statistical significance of the data and eliminate some of the variability in results. We could have chosen different ways to measure physiological stress other than the hand dynameter, for no previous research had indicated that this was an adequate way to assess stress responses and our results agreed with this conclusion. In the future, we could use EEG to record brain activity and ECG to monitor heart activity. Overall, it is recommended that these limitations be considered in order to strengthen results for future studies.

References

Blanchard RJ, McKittrick CR & Blanchard DC (2001). Animal models of social stress: effects on behavior and brain neurochemical systems. *Physiology & Behavior* **73.3,** 261-271.

Faust MW (1992). Analysis of physiological reactivity in mathematics anxiety. Diss. Bowling Green State University.

Gunnar M & Quevedo K (2007). The neurobiology of stress and development. *Annual Review of Psychology* **58,** 145-173.

Inzana C, Driskell J, Sala E & Johnston J (1996). Effects of Preparatory Information on Enhancing Performance Under Stress. *Journal of Applied Psychology* **81,** 429-435.

Jansen ASP, Van Nguyen X, Karpitskiy V, Mettenleiter TC & Loewy AD (1995). Central command neurons of the sympathetic nervous system: basis of the fight-or-flight response. *Science* **270.5236,** 644-646.

Koolhaas JM, Bartolomucci A, Buwalda B, de Boer SF, Flugge G, Korte SM, Meerlo P, Murison R, Olivier B, Palanza P, Richter-Levin G, Sgoifo A, Steimer T, Stiedl O, van Dijk G, Wohr M & Fuchs E (2011). Stress revisited: A critical evaluation of the stress concept. *Neuroscience and Biobehavioral Reviews* **35**, 1291-1301.

Ozel P (2001). Time pressure and stress as a factor during emergency egress. *Safety Science* **38**, 95-107.

Plessow F, Kiesel A & Kirschbaum C (2012). The stressed prefrontal cortex and goal-directed behaviour: acute psychosocial stress impairs the flexible implementation of task goals. *Experimental Brain Research* **216**, 397-408.

Renaud P & Blondin J (1997). The stress of Stroop performance: physiological and emotional responses to color word interference, task pacing, and pacing speed. *International Journal of Psychophysiology* **27,** 87-97.

Sapolsky R (2004). *Why Don't Zebras Get Ulcers: The Acclaimed Guide to Stress, Stress-Related Diseases, and Coping*. Holt Paperbacks, New York.

Wahlstrom J, Hagberg M, Johnson PW, Svensson J & Rempel D (2002). Influence of time pressure and verbal provocation on physiological and psychological reactions during work with a computer mouse. *Journal of Applied Psychology* **87,** 257-263.

Walen SB & SR Williams (2002). A matter of time: Emotional responses to timed mathematics tests. *Educational Studies in Mathematics* **49.3,** 361-378.

Young DL, Goodie AS, Hall DB & Wu E (2012). Decision making under time pressure, modeled in a prospect theory framework. *Organizational behavior and human decision processes*.

Figures and Tables

X	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Figure 1: Standard ten-by-ten multiplication table used for the untimed/familiar and timed/familiar conditions.

B **A**	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Figure 2: Variant of a standard ten-by-ten multiplication table used for the timed/unfamiliar condition. Subjects were asked to complete the table according to the formula f(x)=(A-1)(B+1).

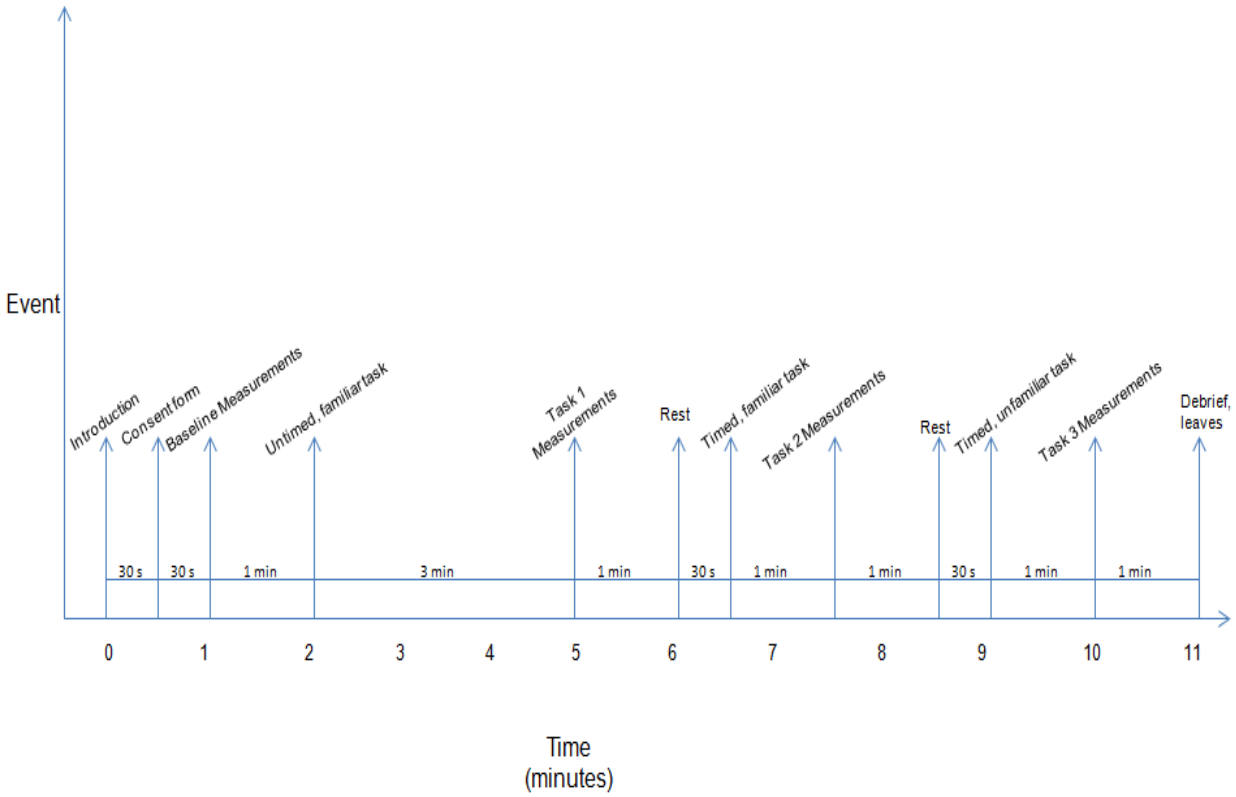

Figure 3: Event Measurements. This figure shows the sequence of the experiment and how long each step will take. All subjects will take approximately 11 minutes to complete the experiment.

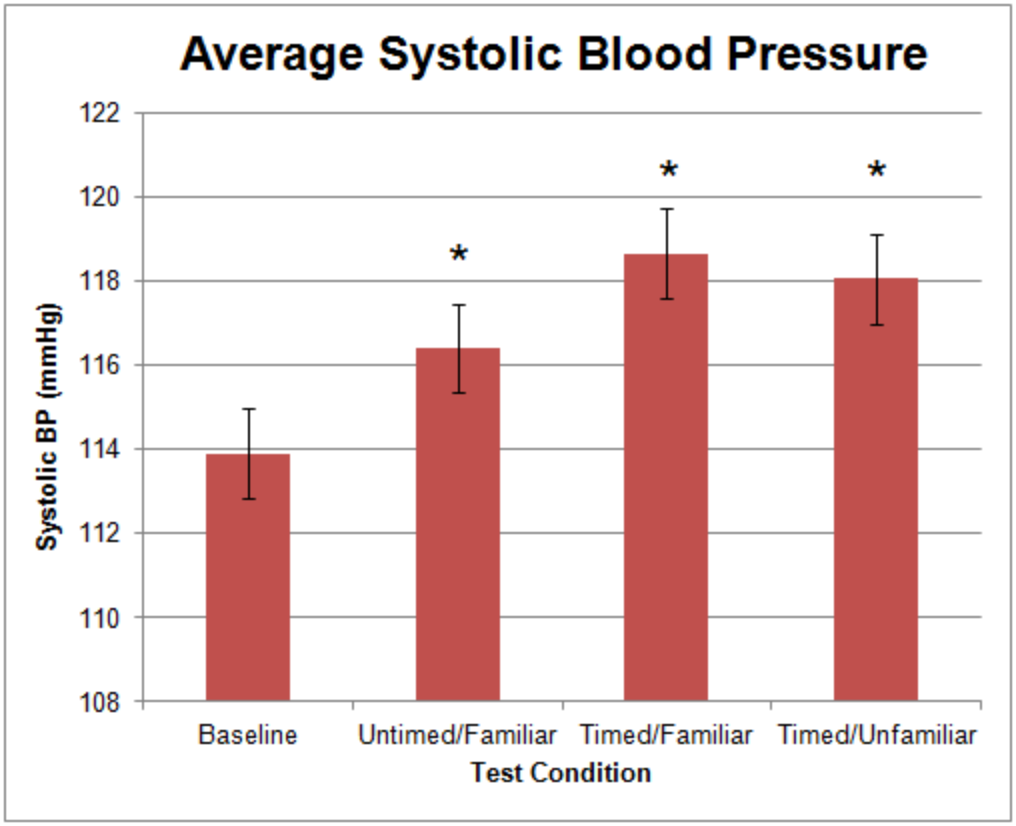

Figure 4: Average systolic blood pressure in baseline and testing conditions.
*****p<0.05 compared to baseline measurement.

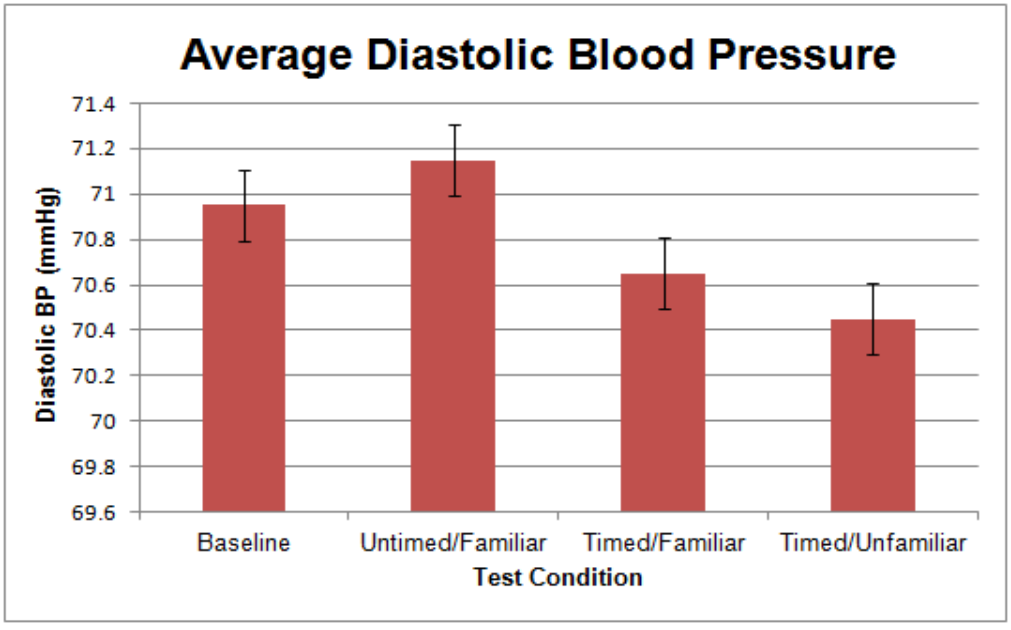

Figure 5: Average diastolic blood pressure in baseline and testing conditions.

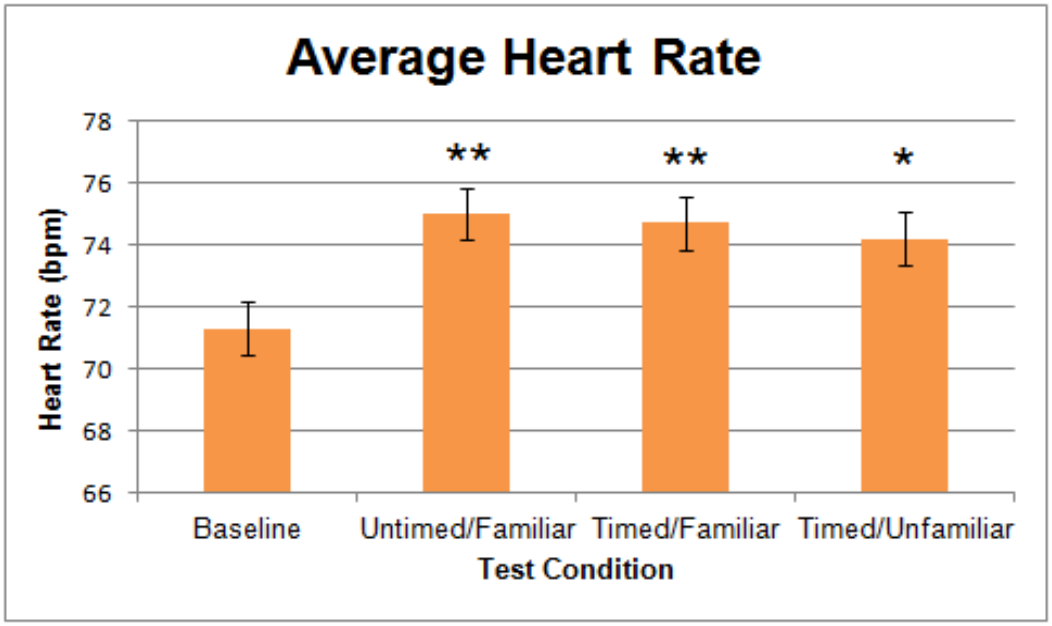

Figure 6: Average heart rate in baseline and testing conditions.
*****p<0.05 compared to baseline measurement.
**p<0.002 compared to baseline measurement.

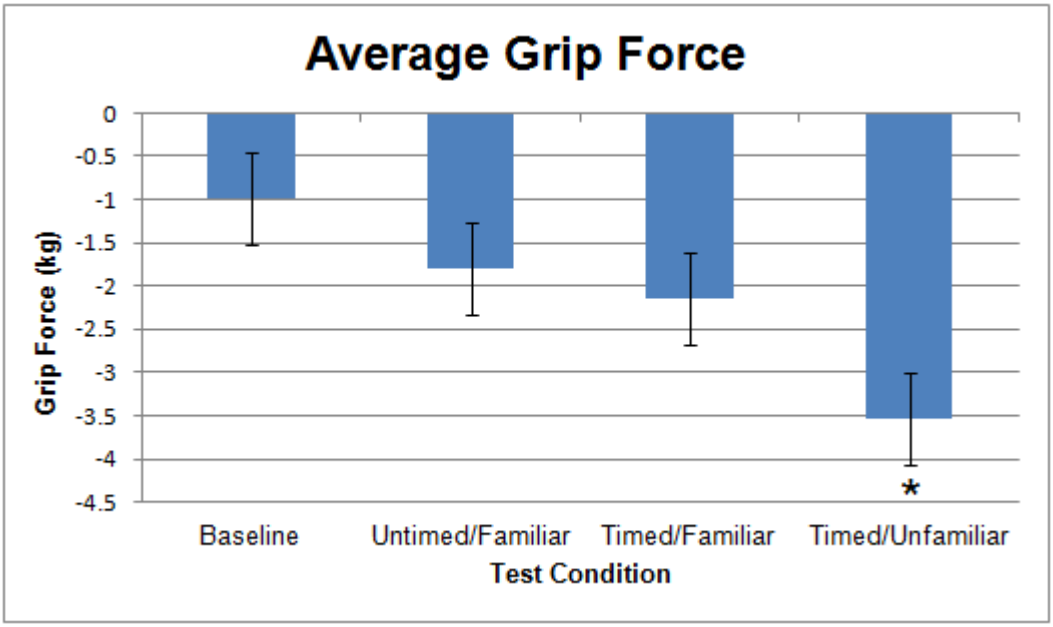

Figure 7: Average grip force in baseline and testing conditions.
*p<0.05 compared to baseline and untimed/familiar measurements.

Table 1. Averages of physiological responses for the baseline and each testing condition.

Condition	**Systolic BP (mmHg)**	**Diastolic BP (mmHg)**	**Heart Rate (bpm)**	**Grip Force (kg)**
Baseline	113.9	70.95	71.3	-0.978213
Untimed/Familiar	116.4	71.15	75	-1.8031375
Timed/Familiar	118.65	70.65	74.7	-2.1388025
Timed/Unfamiliar	118.05	70.45	74.2	-3.5434545

Table 2. Paired t-tests between the physiological responses from each experimental test condition and the baseline measurements.

Condition	**Systolic BP**	**Diastolic BP**	**Heart Rate**	**Grip Force**
Untimed/Familiar	0.054395268*	0.909252503	0.001923979**	0.440022349
Timed/Familiar	0.053008948*	0.893740406	0.001363849**	0.247249971
Timed/Unfamiliar	0.017394163*	0.806080071	0.049191139*	0.035254092*

*p<0.05 compared to baseline measurements.
**p<0.002 compared to baseline measurements.

Table 3. Paired t-tests between experimental conditions examining the effects of time constraints, unfamiliarity of the test, and the combined effects of both.

Condition	**Systolic BP**	**Diastolic BP**	**Heart Rate**	**Grip Force**
Untimed/Familiar vs. Timed/Familiar	0.731574061	0.782613571	0.731574061	0.632019054
Timed/Familiar vs. Timed/Unfamiliar	0.769828434	0.920426202	0.732733329	0.153086697
Untimed/Familiar vs. Timed/Unfamiliar	0.253580308	0.548215184	0.518979715	0.041365893*

*p<0.05 untimed/familiar compared to timed/unfamiliar.