Vigilant Attention, Personality, and Their Implications for Individuals Working in Space

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VIGILANT ATTENTION, PERSONALITY, AND THEIR IMPLICATIONS

Abstract

As Space Tourism is on the rise, more people around the world are getting a chance to travel into outer space. Soon there will be a need for employment in space so it is important to research human behavior in relation to situations in space.The goal of the current study is to use the results for the application of training and working conditions for companies and individuals working in the space industry. A computer based vigilance task was created to measure accuracy and reaction time. The manipulated variables included the frequency of the stimuli, and the working conditions of whether the participant was alone or with another person. Results showed a“trade off” of accuracy and reaction times. Accuracy is greater in the individual condition, yet reaction time is faster in the paired condition. Accuracy is also greater in the frequent condition, but reaction time is faster in the infrequent condition. The strong positive correlation between accuracy and reaction time supports this “trade off” phenomena, meaning when the reaction time is higher, the accuracy is also higher. The vigilance scores of the first half were significantly more accurate when compared to the vigilance scores of the second half, supporting the prediction of the vigilance decrement. The personality variable extraversion/introversion was analyzed across all variables but yielded no significant interactions.

Space Research

The existence of human beings is a fraction of time compared to the existence of the universe. So far, within that fraction of a time, the human race has been able to expand and inhabit an entire planet and begin moving into space. The beginning of space exploration began less than 55 years with the launch of Sputnik in 1957. Since then it has been the goal of nations throughout the world to establish presence in space and obtain new knowledge. In 1969, the first man to walk on the moon expressed this achievement as a "giant leap for mankind". This "leap" will soon be a full on sprint for mankind, as not only nations are pursuing means for deeper space exploration, but also private industries. The Mir Space Station launched in 1986, and the International Space Station constructed in 1998, showed the progress of human capabilities as living in space for long durations of time became possible. Numerous space shuttles carrying astronauts and cosmonauts have orbited the earth and tested the boundaries of human performance including physical and psychological factors. Space probes continue to gather data and pictures of planets and other solar systems that are out of our reach, for now. Remote controlled rovers currently explore the surface of Mars, looking for evidence to suggest life is sustainable on that planet. Dr. Ronald Olowin, astronomer and professor at Saint Mary's College of California, would describe this point in history as the beginning of a "Cosmic Revolution". It may have taken over fifty years to reach the capabilities humans have today, but all that work has set up a foundation and excitement for deep space exploration. With technology advancing at an exponential rate, projections for future missions are being funded and are expected to take place sooner than later. The private organization 100 Year Starship, is a leader in planning for deep space exploration. Started by former astronaut, Mae Jeminson, the 100 YSS just received

funding by the Defense Advanced Research Projects Agency (DARPA) and will begin implementing its program. This new organization promises that within the next century, humans will have the capability of interstellar travel (Jeminson, 2012). If travelling to other solar systems is less than a century away, then what does the more immediate future have in store for us in this "cosmic revolution"?

The commercial space industry has made a huge presence in the plans for space exploration. Companies like Virgin Galactic and SpaceX are pioneers in the new market of suborbital commercial space flight. A ticket to be one of the first 500 people to fly into space with Virgin Galactic costs $200,000. These suborbital space flights, lasting several minutes long, will allow the passengers to experience zero gravity and a spectacular view of Earth (Virgin Galactic, 2012). Not far behind these businesses are innovative companies such as Bigelow Aerospace and Space Island Group that have plans to manufacture and maintain commercial space stations. Facilities like these will make it possible for space tourism to be affordable and commonplace. Private space stations will provide a place to conduct research that can improve life on Earth, and prepare for life in deep space. In the meantime, there are organizations on Earth that are currently doing research in preparation for life in space. The SETI Institute (Search for Extraterrestrial Intelligence) employs over 150 scientists conducting research ranging in disciplines such as astrobiology, engineering, and space ethics (TeamSETI, 2012). The SETI Institute believes that it is not a matter of "if" we (as a human race) will encounter extraterrestrial life, whether it is intelligent or not, but rather a matter of "when". SETI, among other organizations, realizes the rapid growth of the commercial space industry and the increasing possibility of detecting alien life (TeamSETI, 2012). SETI organizes conferences and programs to involve the general public in discoveries and ideas, and to get people excited about

space exploration.

Why is Space Exploration important? Whether you like it or not, space exploration seems to be inevitable. Although venturing into the unknown can be terrifying, it is human nature to explore and be curious (Lin, 2006). Exploring and developing in space is important because it is already a huge investment of the future. What once were concepts and science fiction, are now actual plans and projects (Jeminson, 2012). With space tourism on the rise, space travel will soon be a reality for the average Joe, not just a fantasy seen only in movies. Because the overall goal of space exploration is to drive economy with commercial industry as well as to push the limits of human intellectual and physical capabilities, objections to its significance does not seem to be a dilemma but rather the ethical issues that will arise in space (Lin, 2006). Who will determine ownership? What type of government will there be in a place of international use? Will there be a police force to enforce laws? Will there be laws? Questions like these are being discussed all over the world as companies and organizations grow closer to lift-off. If the right decisions are not made then it could manifest situations of conflict and war between humans in space. Currently there is constant pressure on all nations to have better international collaboration, so that conflict can be avoided and space exploration can be a shared achievement of humans as a species, instead of a single nation or corporation (Jeminson, 2012).

As commercial space companies and government space programs grow, so will employment, not only on Earth. Recently there has been a high demand for engineers as companies are building their spaceships and space centers. With private space shuttles and space stations planned to be launched more frequently, there will be more opportunities to be employed and sent into space, and not necessarily be an astronaut. Eventually, private space stations and other tourist vehicles will be in need of pilots, security, customer service providers,

maintenance specialists, and do not forget, researchers, all working in space. For example, the Space Island Group is confident that by the year 2020 they will be able to employ 20,000 people on their space stations. Working in such an extremely different environment such as space, is an experience that only astronauts have had the opportunity to do. One can assume that the training of these thousands of future space employees will not be as intensive as the years of rigorous training done by previous astronauts. This calls for the need of more research and training programs, that can be used by private industries to send individuals into space to work. The study of how people work and the methods of training, depend greatly on the field of psychology. Although there is limited access to conduct psychological research in space, research can still be done regarding working conditions here on Earth, that could be used for better understanding of working in space. For example, a typical working situation that current space crew members are constantly experiencing is the psychological phenomena of sustained vigilant attention. In other words, crew members are faced with challenges of staying alert and aware for several hours and even days at a time. Sustained concentration and being ready to react can be a challenging objective without the added pressures of being in space. As more people start entering the cosmic space, it will be important to inform people about the human capacity for vigilant attention and recommendations for preparing for situations or jobs in space that require intense focus.

Vigilance Research

Vigilance, also known as sustained attention, is the ability to maintain concentration or awareness for a long period of time. Vigilance was first defined in 1926, as the mental and physical readiness to process and react, and was first studied in 1947 by Norman H. Mackwork . It was observed that radar operators in Navy submarine ships during World War II, were

constantly subject to long periods of prolonged visual search (Mackworth, 1947). Performance of the radar operators significantly decreased in efficiency over time, so there became a need to find the optimum amount of time that someone could maintain vigilance before performance was impacted . Mackworth designed a study that mimicked the vigilance requirement of a submarine radar and called it The Clock Test. Subjects of this test were asked to focus on a ticking hand of a faceless clock and indicate when the hand jumped twice as much as usual. The test required the participants to stay alert for two hours. This long duration made it possible for Mackworth to observe the phenomena of the vigilance decrement, which is the gradual decrease in detection of stimuli over time. The longer the participants stared at the watch, the less likely they were to detect the jump of the clock hand and respond correctly (Mackworth, 1947).

The Clock Test was an important study of sustained attention that influenced more recent studies of this topic. A study done by Litchstein, Riedel, and Richman in 1998 tried to duplicate the methodology of Mackworth's original study, with an exception to the testing instrument. Litchstein et al. used a computerized experiment to perform the vigilance test and record the subject's responses. Results of this study supported the findings of Mackworth, as deterioration in detection was evidence of the vigilance decrement. Research done by Helton and Russell, explore the reasons for the vigilance decrement while using a known computer-based vigilance task. Two current theories of why the vigilance decrement occurs are the under-load theory and the resource theory. The under-load theory claims that people become bored when maintaining vigilance which causes a lack of arousal and attention. Also, this theory suggests that people may respond to the boredom with distracting thoughts and increase the likelihood of the vigilance decrement. The resource theory argues that vigilance tasks cause a mental overload because of the constant focus without rest. Because there is a lack of rest and resources, the brain has a

harder time processing information and efficiency decreases (Helton and Russell, 2011).

Another well known vigilance task is the Sustained Attention to Response Task (SART) developed by Manly, Davison et al. The SART test asks participants to watch a screen and respond to each stimuli with the exception of one specific stimuli. When the specific stimuli occurs, participants are asked to refrain from making the same response as previously made. For example, when the computer shows a digit on the screen, the participants are asked to respond by pressing a certain button. When the number 3 appears on the screen, the participants are asked to refrain from pressing that certain button. This method of assessing sustained attention is different than that of Mackwork and previous studies mentioned, because it requires participants to inhibit an ongoing behavior as opposed to making a certain response to a stimuli. An article by Robertson and Garavan (2004) discussed this difference in testing vigilance and argues in favor of withholding from a response to demonstrate vigilance. The inability to inhibit a repeated response can be caused by a lack of attention, and can be proof of the vigilance decrement.

Current Research

As the industry of Space Tourism is expanding, more people around the world are getting a chance to travel into outer space. Before long, possibly even the next couple of decades, it will not be unlikely that various job opportunities will be in demand that take place outside of this earth. When this happens, it will be very important to know how people with different personality traits and in different working conditions, will be able to concentrate and work vigilantly. It starts with experiments on Earth like this one, that measure different variables regarding vigilance. With this knowledge, we as a human race, will be able to train ourselves appropriately for the situations that will occur in space. The purpose of the current study is to use the results for the application of training and working conditions for companies and individuals

working in the space industry.

A computer based vigilance task was created to measure the dependent variables, accuracy and reaction time of the participants. The vigilance task was created with the influence of Mackworth's Clock Test, as well as the SART test. Like Mackworth's Clock test, the current vigilance task asks the participant to correctly respond to a frequently occurring stimuli. In addition, the current vigilance task asks that participants withhold from a repeated response when a certain stimuli appears, much like the method of the SART test. The current vigilance task displays a series of sequences of numbers, each containing six digits at a time. Each sequence of numbers is shown for a little over one second before moving on to the next sequence. Participants are asked to respond correctly and as quickly as possible. Instructions state that if the number 4 is present in the sequence of numbers, respond by pressing the red button. If the number 4 is absent from the sequence of numbers, respond by pressing the green button. Depending on the condition of the participant, the frequency of the number 4 is much more often than the other. In the condition that the number 4 occurs less often, participants are forced to inhibit their repeated response of pressing the green button when the number 4 infrequently occurs, and respond differently than usual. In the condition that the number 4 is present more often, participants are asked to make a response when the 4 appeared more frequently. Accuracy and reaction times of the participants' responses are recorded as dependent variables.

The current research assesses the vigilance of participants in several different conditions. Conditions were chosen to represent variables of general situations that occur in space. The independent variables included the frequency of the stimuli, and the working conditions of whether the participant was alone or with another person. The vigilance scores of the first half are compared to the vigilance scores of the second half, and the personality variable

extraversion/introversion is analyzed across all variables.

The first manipulated independent variable in the study is the frequency of the stimuli in the visual vigilance task. Half of the participants experience a task with a low frequency of stimuli, and the other half experience a more frequent stimuli. This means that half of the participants encounter the number 4 less frequently with longer intervals of time between the next 4. The other half of the participants encounter the number 4 more often with shorter intervals of time between the next 4. Less stimuli may cause the participants to become less concentrated due to boredom, and more stimuli may make it easier to stay interested and focused. Keeping in mind the under-load theory, we predict that participants who experience the vigilance task with more frequent stimuli, are more likely to have better accuracy than the other group.

The second variable being measured in the experiment is a repeated-measures variable. With the scores from both dependant variables, early stages of the vigilance task can be compared to the later stages. Scores from the first half of the experiment are compared to the scores in the second half. In past research, it was found that as time goes on vigilance decreases (Dinges and Powell, 1985). We predict scores from the first half of the test are faster in reaction time and more accurate than those of the second half. The counterargument to this theory is the belief that performance will increase over time with repeated exposure. Current recommendations to reduce vigilance decrement is to practice more (Loh, Lamond, Dorian, Roach, & Dawson, 2004). The longer the vigilance test is, the more practice and exposure the participants experience, so there is a possibility that they may do better in the later stages of the task after they have had more practice.

Another manipulated variable in the study is whether or not the participant completes the vigilance task alone or with one other person. In the condition with two participants working together on the vigilance task, it is expected that the psychological phenomena of social loafing will occur. Social loafing is the tendency to use less effort in a task when working with others. In a study done by Latané, Williams, and Harkins, in 1979, the level of effort given to the task of yelling and shouting was nearly 20% less when the participant believed they were in the presence of another participant with the same task, than when alone. To test this theory, we predict that individuals working alone on the vigilance task should yield better results than those working in pairs. In a situation of social loafing, it is expected that there will be a diffusion of responsibility in which each individual exerts less effort toward accomplishing the task because of the assumption that others will invest more responsibility. This idea comes from the study of Darley and Latane in 1968, on their research on Bystander intervention. The study supported the hypothesis that in an emergency situation, individuals are more pressured to intervene when they are the only witness, but when others are present, the pressure to intervene is shared and people feel less responsible. It is important to know if this phenomena occurs in groups of two during vigilance tasks, so conclusions can be drawn to determine good strategies for training.

A personality trait is evaluated in the study, with a focus on extraversion/ introversion. Of the Big Five personality traits, extraversion was chosen because it is more often than not, a common trait of astronauts (Musson, Sandal, and Helmreich, 2004). Extraverted people usually known for enjoying excitement, adventure, and social crowds. Extraverts seek out excitement and social situations because they have faster reductions in cortical arousal to stimulation than introverted people. They are more attracted to stimulation because they are naturally more sensitive to it. Introverts on the other hand, are socially distant and emotionally

reserved. Participants of this study are measured for their level of extraversion/introversion using the NEO Personality Inventory (McCrae and Costa, 1987). With this data, differences between extraversion/introversion and any of the other variables can be found. Vigilance tasks are typically considered boring, low stimulation tasks, which gives introverts an advantage because they respond better to situations with less stimuli. Our hypothesis is that participants with a higher level of introversion will perform better on the vigilance task when working alone, than participants of high extraversion working alone. Because extraverts thrive with more stimulation, we predict that they will do better than introverts when another person is present, because it raises the level of stimulation. In the frequent condition, an increased level of stimulation is expected from the number 4 appearing more often, so we predict that extraverts will do better than introverts in this condition. Furthermore, we predict extraverts will perform worse over time due to the increase in boredom. Extraverts are expected to score worse on the second half of the experiment because of the decrease of stimulation.

Method

Participants

Participants were all affiliated with Saint Mary's College of California. Participants were either faculty, staff, or students. The total number of participants in this study was 58, but only 37 valid sets of data. All participants were between the ages of 18 and 48. There were 21 males and 16 females that participated in this study. Participants were randomly assigned to one of four conditions. For participants in the alone condition, 9 subjects experienced the frequent condition, and 7 subjects experienced the infrequent condition. For the participants working in the paired condition, 22 subjects experienced the frequent condition, and 20 subjects experienced the

infrequent condition. Because only one set of data could be recorded at a time, half of the participants in the paired condition did not have valid data. In the paired condition, only 11 subjects contributed valid data for the frequent condition, and only 10 subjects contributed valid data for the infrequent condition.

Materials

A consent form was given to participants upon arrival, attached as Appendix A. Participants were asked to complete a portion the NEO Personality Inventory that only consisted of questions to determine the level of extraversion/introversion, attached as Appendix B. This personality inventory contained 15 statement with numbers 1 through 5 directly under each statement for participants to record their response. Participants were instructed to read each statement and circle the number that best represents their opinion. 1 represented strongly disagree and 5 represented strongly agree. There were 12 questions that assessed the participant's levels of Extraversion/Introversion, with 3 questions of those questions being reverse coded. The remaining 3 questions of the 15 total, were unrelated to the assessment and were used as distractor items.

A computer based vigilance task was given to the participants. This vigilance test was created by the experimenter using the program E-Prime by PST. This vigilance test was similar to previous computer programs that measure vigilance, such as the Sustained Attention to Response Test (SART). Similar to SART, the vigilance task in this study presents a series of numbers and asks the participants to respond appropriately. This particular vigilance task displayed a series of 6-digit sequences, and asked the participants to respond by pressing a designated green button when the number 4 was present in a sequence. The participants were instructed to respond by pressing the designated red button when the number 4 was absent of the

sequence of digits. Because vigilance was being measured by accuracy and reaction time, instructions were given to participants asking them to respond correctly and as quickly as possible. The vigilance task provided a brief practice run that allowed the participants to become accustomed to the display and buttons before beginning the actual test. The actual test contained 300 trials, containing 6 digits in each sequence. In the frequent condition, there were 78 trials in which the sequence of numbers in each trial contained the number 4. The remaining 222 trials did not contain a single 4 in any of the sequence of numbers. The vigilance task automatically randomized the order of the trials. The placement of the number 4 in each of the 78 trials was equally distributed. The number 4 appeared in each place in the six-digit sequence 13 times, to avoid biases of visual placement. In the infrequent condition, there were 24 trials in which the sequence of numbers in each trial contained the number 4. The remaining 276 trials did not contain a single 4 in any of the sequence of numbers. The vigilance task automatically randomized the order of the trials. The placement of the number 4 in each of the 24 trials was also equal. The number 4 appeared in each place in the six-digit sequence 4 times, to avoid biases of visual placement.

A Post-Experiment questionnaire was given to the participants, attached as Appendix C. The questionnaire contained six questions assessing the participants' opinions on their performance on the vigilance task, with responses in the Likert Scale format. For example, questions asked participants to report his or her level of confidence, interest, difficulty staying alert, etc. A score of 1 represented Very Easy or Not at All, and a score of 7 represented Very Difficult, or Very Important. The questionnaire also asked the participants to indicate his or her age and gender.

Procedure

Participants were gathered by asking people on campus or friends of the experimenter to participate. A coin was flipped to determine first whether the participant was assigned to the condition in which they would take the vigilance task alone or with another participant. In cases of the paired condition, participants were randomly paired with another participant that they may or may not have known. The Participants were settled in a quiet environment and given a consent form to read and sign, acknowledging that they understood the purpose and risks of the study, as well as to give the experimenter permission to continue. The participants were then given the portion of the NEO Personality Inventory and asked to follow the instructions. Following the completion of the NEO-PI, a coin was flipped again to determine whether the participant would take the vigilance task in the condition of frequent stimuli, or in the condition of infrequent stimuli. Participants were then stationed at a computer that ran the vigilance task through the E-Prime software. Participants were asked to follow the instructions on the screen. After the completion of the vigilance test, the participants were handed a Post-Questionnaire survey and asked to fill it out. Following the questionnaire, a debriefing form (Appendix D) was given to the participants as well as a $10 gift card for compensation. Participants were thanked for their time and participation and dismissed.

Results

Participants in the study were given a computer-based vigilance task that asked them to respond to each sequence of numbers correctly and as quickly as possible. If the number 4 appeared in a sequence of digits, participants were asked to respond with a specified key. If the number 4 was absent in the sequence, participants were asked to respond with a different specified key. Accuracy was measured by the correctness of the participants' responses to the

vigilance task when the stimuli, the number 4, was present. Accuracy and Reaction Time scores were subject to a series of analyses of variance having two levels of frequency (frequent versus infrequent) two levels of working conditions (individual versus paired) two levels of time (first half versus second half) and two levels of personality (introvert versus extravert).

The personality variable of extraversion versus introversion, was subject to a series of analyses to test the effect on accuracy and reaction time. In both analyses, there was no significant impact of the extraversion/introversion scores on either accuracy or reaction time. The effect of time on accuracy and reaction time in the conditions of extraversion versus introversion, also yielded no significant results $p > .10$. There was no real difference in accuracy and reaction time between the first half and second half scores of the extraverts versus the introverts, nor was there any significant interaction between the personality variable and any of the independent variables in the study. Therefore, the personality variable was dropped from all further analyses.

The variable of frequency was measured by comparing two conditions that only differed in the how frequent the number 4 occurred throughout the vigilance task. In the infrequent condition, participants were shown the number 4 much less than participants in the frequent condition. The effect of frequency on accuracy yielded an F ratio of $F(1,33)=3.124$, $p < .10$. The strength of the relationship , as indexed by partial eta2, was .09. The mean difference for accuracy when the number 4 was present for participants in the frequent condition ($M = 86.0\%$) was marginally greater than the mean accuracy for participants in the infrequent condition ($M = 78.0\%$). In general, participants who were exposed to the number 4 more frequently were correct 86 percent of the time. This supports our hypothesis that participants in the frequent condition would do better overall when compared to participants in the infrequent condition who, in

general, correctly identified the number 4, 78 percent of the time.

To compare the difference in working conditions, participants completed the vigilance task alone or with a partner. We hypothesized that the participants working individually would score better overall than those in the paired condition. The effect of working conditions on accuracy yielded an *F* ratio of $F(1,33)=3.47$, $p <.10$. The strength of the relationship, as indexed by partial eta2, was .10. The mean difference for accuracy when the number 4 was present for participants in the individual working condition ($M = 86.2\%$) was marginally greater than the mean accuracy for participants in the paired condition ($M = 77.7\%$). Our hypothesis was supported by the results of the individual condition in which participants correctly responded 86.2 percent of the time compared to the results of the paired condition with an overall accuracy of 77.7 percent of the time.

As we predicted, participants in the frequent condition responded more accurately than those in the infrequent condition. However, it was interesting to see if the participants in the frequent condition would perform better in terms of reaction time as well. The effect of frequency on reaction time yielded an *F* ratio of $F(1,33)=35.23$, $p < .01$. The strength of the relationship , as indexed by partial eta2, was .52. The mean difference for reaction time for participants in the frequent condition ($M = .57$ seconds) was significantly longer than the mean reaction time for participants in the infrequent condition ($M = .48$ seconds). Participants who encountered the number 4 less often, responded much faster than those who encountered it more frequently.

The effect of working conditions on reaction time yielded an *F* ratio of $F(1,33)=8.16$, $p < .01$. The strength of the relationship, as indexed by partial eta2, was .20. The mean difference for reaction time for participants in the individual working condition ($M = .55$ seconds) was

significantly longer than the mean reaction time for participants in the paired condition (M = .51 seconds).

A Pearson Correlation was computed to assess the relationship between the accuracy and the reaction time of the participants. There was a positive correlation between the two variables, r = .640, p < .001. An increase in accuracy is strongly correlated with an increase in reaction time.

The scores of the vigilance task were divided into two halves in order to look at the differences in scores over time. It was predicted that the scores of the first half would be better overall than those of the second half. The effect of time on overall accuracy, yielded an F ratio of $F(1,33)=8.07$, p < .01. Accuracy scores in the first half of the experiment were significantly higher than the accuracy scores of the second half. The effect of time on reaction time yielded no significant results.

Specifically, the effect of time on accuracy for participants in the infrequent condition showed no significant results, p > .10. There was no significant difference in accuracy scores between the first half and second half of participants in the infrequent condition. We did not expect a difference in the first half, but we did predict a decrease in correct responses from those in the infrequent condition because of the increased level of boredom. The results did not support this prediction.

Discussion

Half of the participants experienced the vigilance task alone, and it was predicted that they would produce better results overall than the other half of the participants who worked with another person. Participants in the individual working condition did better overall in accuracy than those in the paired condition. Although this result was only marginally significant, it

supports the hypothesis that participants working alone on the vigilance task will yield better results than those working in pairs. There are a couple possible reasons for this outcome. In the condition of participants working in pairs, there is the possibility of participants becoming subject to the phenomena of diffusion of responsibility. The participants may have felt less pressure to do as well on the vigilance task if they knew that there was another person next to them that could respond correctly to the stimuli. Another possible reason for this result could have been the fact that the participants in the paired condition were simply more distracted because there was another person in the room. If a participant is thinking about the person next to them, then they most likely have less focus on the experiment and fail to respond correctly when the stimuli occurs. There were no specific instructions in the experiment that prohibited communication between participants working together, so it is possible that there was conversation between participants, which increases the likelihood of distraction and errors. Despite the lower accuracy scores, the participants in the paired condition responded significantly faster than those in the individual condition. One possible explanation for this result is the level of competition that was formed by the participants working together. If one participant was concerned with how fast he or she responded in relation to the person next to them, they may focus less on their accuracy and more on their reaction time so they could at least be faster than the other person. This is likely because the participants could hear the clicking of the keyboard when they responded, but they could not necessarily see each of the responses.

Half of the participants encountered the stimuli, which was the number 4, much more frequently than the other half. This condition of higher stimulus frequency was predicted to score better overall than those who encountered the number 4 much less often. Participants in the

frequent condition did better overall in accuracy, than those in the infrequent condition. This finding was also only marginally significant, yet it too supports the hypothesis that participants who experience the vigilance task with more frequent stimuli are more likely to have better accuracy than the other group. With more frequent stimuli in the experiment, participants in the frequent condition were most likely more interested in what they were doing. The increased frequency of the stimuli made the participants have to pay more attention to the numbers and "search" for the number 4. Because of the increased stimulation from "searching", participants gave more attention to the vigilance task. Also, the participants in the frequent condition were exposed to the number 4 much more than those in the infrequent condition, so they had more practice at "searching" and responding correctly when the 4 was present. Participants in the infrequent condition were more likely to become bored by repeating the same action for long periods of time. Boredom may have caused these participants to focus less on the experiment because of the lack of interest. Another possible explanation to note is that because the stimuli occurred so infrequently, the participants in this condition most likely became habituated with pressing the same button over and over. Unlike the frequent condition in which participants were searching for the number 4, this condition required that participants "inhibit" their ongoing behavior of pressing the same button and respond with another button. Another element to keep in mind is the sensitivity of measuring accuracy in each condition. If a participant responded incorrectly when the number 4 appeared in the infrequent condition, it would decrease their accuracy score much more than a participant who incorrectly responded to the number 4 in the frequent condition. Regardless of their performance in accuracy, participants in the frequent condition were significantly slower than those in the infrequent condition. Slower response times in the frequent condition could be related to the "searching" for the number 4.

The participants in the frequent condition may have taken a fraction of second longer on each trial because they knew the number 4 would show up often. The participants in the infrequent condition became used to pressing the same button so many times that they most likely expected there to be no number 4 on the next trial, which caused them to respond faster.

What is most interesting about these results is that there is an apparent "trade off" of accuracy and reaction times that holds true for both independent variables, frequency and working condition. Accuracy is greater in the individual condition, yet reaction time in faster in the paired condition. Likewise, accuracy is greater in the frequent condition, but reaction time is faster in the infrequent condition. The strong positive correlation between accuracy and reaction time, as shown in the Pearson correlation analysis, supports this "trade off" phenomena. When the reaction time is higher, the accuracy is also higher. This "trade off" can be used to the advantage of the application depending on the desired effect. For example, if reaction time is desired in a task that requires vigilance, conditions in which there are infrequent stimuli or another person present, are suggested. One suggestion for faster performance in sustained attention for individuals working in space may be to work with other people, or at least with one other person. It may be unlikely to have control of the frequency of a stimuli in a task that requires vigilance in space, but if there is an activity that involves a low frequency, one can expect reaction time to be faster. If accuracy is desired in a task that requires vigilance, conditions in which an individual can work alone is recommended. Individuals working with sensitive equipment in space or on Earth, should minimize the likelihood of distraction and increase their conditions for better accuracy by working alone. If frequency cannot be controlled, one can expect that their performance in accuracy should be greater if something occurs more often.

The scores of the vigilance task were split into first half and second half groups and compared for any significant differences. It was predicted that the scores from the first half of the experiment would be better overall than those of the second half, because of the vigilance decrement. Results for the time variable were only significant for the measures of accuracy, not reaction time. There was no significant change in reaction time of the participants between the first half and the second half of the vigilance task. Across all conditions, accuracy was much greater in the first half of the experiment than the second half with a .01 level of significance. This result partially supports the hypothesis that scores of the first half will be better overall than those of the second half. The opposing viewpoint that performance will improve over time with more practice and repeated exposure did not hold true in this study. It is likely that the participants were impacted by the vigilance decrement, which caused them to be less accurate over time. There was a slight decrease in reaction time in the second half of the experiment but not enough to be statistically significant. Stronger results may be obtained with a larger sample size. It was predicted that accuracy would be worse in the second half than the first half in the infrequent condition. This specific prediction was made because of the anticipated higher level of boredom that may be caused by the very infrequent stimuli. This prediction was not specifically supported by the results, $p > .10$, but with a larger sample size an impact in accuracy may occur.

A personality variable was examined to assess the relationships of three hypothesized interactions. It was predicted that the participants with higher scores on the NEO-PI test (extraverts) would perform better overall in the paired condition, because of the increased stimulation of working with another person. Furthermore, participants who scored lower on the NEO-PI test (introverts) were expected to perform better in the individual condition, because of

the lower levels of stimulation of being by oneself. Another predicted interaction of the personality variable was that extraverts would perform better overall in when in the frequent condition, simply because frequently occurring stimuli provides more stimulation. Additionally, extraverts were expected to do worse in performance over time, because of the increase in boredom from the repetition, which would cause a decrease in stimulation and attention. Unfortunately, all interactions involving the personality variable yielded no significant results to report.

The lack of results from the personality variable may be due to a couple of reasons. Firstly, the vigilance task itself may not have been designed specifically enough to show a difference in scores between participants with different levels of extraversion/introversion. It may need to be longer or have different frequency stimulation to show a difference in participant scores, for example. Another possibility for the lack of significance is the sensitivity of the NEO-PI test. This inventory may not have accurately assessed the level of extraversion/introversion of each participant and did not reflect the actual number of extraverts and introverts in each condition. This may have caused the personality data to be more similar overall, making it less likely to distinguish differences. A possible method to avoid this lack of sensitivity is to split the extraversion/introversion scores into three groups: lowest, middle, and highest scores. Then omit the middle scores which are the most similar to one another, so that only there is a clearer distinction between the extraverts and the introverts. In order to use this method for more sensitive extraversion/introversion scores, there must be a larger sample size because most participants will most likely have scores in the middle section. There needs to be a large enough sample size so that the highest and lowest scores are representative of the population and not consisted of only outliers.

An important limitation of the current study was the sample size, which included 37 valid participant scores. Collection of participants and data will continue, until a more appropriate sample size is collected. A more sensitive analysis of the personality variable will then be possible. Results regarding the other variables in the study, frequency, working conditions, and time, are currently in the right direction for supporting the hypotheses, but more data is needed for strong statistical significance.

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