Different Attentional Functioning and Vigilance Under Trait Anxiety: An Experimental Study

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Original Article

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Abstract

During recent years, the interest in measuring vigilance has increased. Furthermore, trait anxiety differently impacted different systems of attention, but the impact of trait anxiety was not previously measured with vigilance. That's why the current study was designed to measure the impact of trait anxiety on attentional systems and vigilance (executive and arousal). This is an experimental study with 56 on-campus psychology students (males=12, and females=44) aged 19-28 years. The participants' selection criteria were their scores on the state-trait anxiety scale by Spielberger (1983). Participants who scored 20-37 on STAI-T participated in a low-trait anxiety group and the participants who scored 45-80 participated in a high-trait anxiety group. Both groups performed ANTI-Vea tasks to measure attention and vigilance. After task completion, participants again filled out STAI-T to ensure they were assigned to the relevant group. Three repeated measure ANOVA was used for analysis. The results revealed that as compared to the anxiety group of high traits, alerting and orienting networks of the low trait group were less effective. There exist no significant difference in accuracy and reaction time in both group. No evidence of executive and arousal vigilance decrement was documented. In conclusion, it is evident from the findings that using 4 blocks in the ANTI-Vea task is not so efficient for showing vigilance decrement. Future studies could use all 6 blocks of the task to exhibit vigilance decrement.

Keywords: Attention Network Test, warning signals, visual cues, executive control, arousal vigilance, executive vigilance, high anxiety trait, low anxiety trait

1. Introduction

With the growing use of machines and technology like radar, the need to detect and monitor infrequent events increased and the researchers took great interest in the concept of vigilance. Vigilance is not a single concept; it is quite difficult to assess vigilance especially when the task demands high engagement. Whilst vigilance is the ability to notice serious events over an extended period (Warm *et al.,* 2008).

Roca and his colleagues took great interest in measuring two components of vigilance systematically and developing behavioral tasks which assess different functions of attention along with vigilance (2018). The executive vigilance decline is typically seen as a tendency to notice less

important events over time (Helton et al., 2007). There has been much discussion on whether the decline is caused by a shift in response bias or a lack of sensitivity to distinguish between normal and unexpected events (Langner and Eickhoff, 2013). The decline would be linked to an increment in response bias toward a more conservative criterion, according to Thomson and his colleagues (2016) like participants strive to commit fewer errors as time goes). Alternately, some aspects of behavior involved vigilance more than just being accurate in seeing infrequent targets. For instance, in clinical neuropsychology, the term "vigilance" often refers to the various arousal levels during the cycle of sleep-wake rather than behavioral response (Oken *et al.,* 2006).

Defining attention in terms of subjective experience is somewhat easy, as everyone knows about attention. It can be similar to taking control of the mind (James, 2007). Posner and colleagues suggested that the system of attention is composed of three separate neural networks that are capable of interacting with one another (Petersen and Posner, 2012). The superior colliculus, temporoparietal junction, and frontal fields of the eye are all included in the posterior orienting network. The orienting network focuses on probable spatial sources of pertinent inputs and takes advantage of spatial cues that accurately forecast their locations (Posner, 2016). Second, the parietal and frontal parts of the right hemisphere influence the alertness network. This network controls two distinct processes: (a) phasic alertness, which is the brief increase in alertness brought on by using warning signals; and (b) vigilance, or the tonic alertness needed to continue performing for an extended amount of time (Posner, 2008). Finally, the dorsolateral part of the prefrontal cortex and the anterior cingulate are part of the executive control network. This system controls behavior in conflict situations so that we can accomplish our objectives (Shenhav *et al.,* 2013).

Fan and his colleagues created the Attentional Network Test to simultaneously measure each attentional network independently (2002). Later, Callejas et al. (2004) replaced stimuli by measuring phasic alertness and orienting to analyze interactions between the attentional networks. It's interesting to note that both ANT and ANTI did not offer a specific indicator of vigilance over time. Some research suggested that overall performance or the difference between the final block of trials and the first block might be used as indirect alertness indicators (Ishigami and Klein, 2010). Therefore, Roca and colleagues created the task of ANTI-Vigilance (2011) to offer a precise measurement of vigilance. Later, Luna and his colleagues (2018) developed Attention Networks Test with Interactions & Vigilance (executive & arousal). This new version of the task addresses prior problems in the assessment of executive vigilance (EV) and incorporates direct measure of arousal vigilance (AV). Moreover, traditional attentional functions are also measured.

Anxiety is often used interchangeably with stress and threat, but it is quite different from these. According to Spielberger, these terms differ from one another as, stress is related to some situations, the threat is connected to the impression of the person of danger, and anxiety is connected to a person's emotional reaction to a frightening circumstance. According to Spielberger, the two distinct anxiety notions are trait and state. The general form of anxiety or anxiety-prone is known as trait anxiety (2013). Trait anxiety is a personality trait that has remained relatively consistent over time. It is a long-term anxiety level (Caumo et al., 2000). According to certain studies, those with high-trait anxiety strongly engage attention more than people with low-trait anxiety (Koster *et al.,* 2006).

The focus of the theory of attentional control is on anxiety and cognition. Instead of focusing on clinically anxious people, it focuses on anxiety in the general population. Additionally, it emphasizes the individual differences in anxiety as a personality trait. It is an assumption that

anxiety enhances attention when confronted with threat-related stimuli. Therefore, anxious people devote more internal or external attention to threat-related stimulus (Eysenck et al., 2007).

1.1 Significance of the Study

For the last several years, researchers were trying to develop an appropriate parameter to assess arousal and executive vigilance decrement together with the interaction of networks of attention. Luna and his colleague developed the ANTI-Vea task to measure it and concluded that it is a suitable task to measure attentional networks independently with interaction, together with AV and EV decrement (2021). Though the impact of anxiety was measured on attention previously (Pacheco-Unguetti *et al.,* 2010) but the phenomenon of vigilance decrement was still not measured along with anxiety. So, the present study was designed to measure the impact of trait anxiety on attention and vigilance. Moreover, there was no experimental study measuring trait anxiety, attention, and vigilance in Pakistan before. The present study provides novel findings of its type about the population of Pakistan.

1.2 Objectives of the Study

To find out the effect of trait anxiety on different attentional functioning

To investigate the impact of trait anxiety executive and arousal vigilance

1.3 Hypothesis of the study

1. Trait anxiety groups will likely to perform faster in tone, valid cues and congruent conditions than in no-tone, invalid cues and incongruent conditions respectively.
2. Trait anxiety groups will likely perform more accurately in tone, valid cues and congruent conditions than in no-tone, invalid cues and incongruent conditions respectively.
3. Low anxiety groups will likely perform faster and more accurately in alerting, orienting, and executive control than high anxiety groups.
4. Trait anxiety groups will likely show a significant difference in mean the RT of AV and in the Hits of EV.
5. Arousal decrement will cause reaction time increment and executive decrement will likely cause response biasness increment.

2. Literature Review

The research into the association between anxiety and attention is proceeding. Trait anxiety has a negative association with attentional control, while attentional control acts as a low mediator between mindfulness and trait anxiety (Walsh et al., 2009). Brunye and his colleagues (2010) investigated the impact of caffeine on attentional networks. It was found that caffeine differently affects different functions of attention. It improved the activity of alerting and executive control while orienting control is less efficient. Sleep deprivation differently affects attentional functions and vigilance. It was claimed sleep deprivation causes slowing reaction time and results in decreased vigilance. Moreover, it affects executive control and orienting (Martella *et al.,* 2011).

While studying the role of the development of attentional networks during childhood, it was concluded that children exhibit independence in three networks of attention under some circumstances. At each level of age, accuracy and reaction time keep improving. The orienting scores do not change across age, while evidence showed that alertness keeps changing up to and beyond the age of 10. The conflict scores appeared to be stable after the age of seven (Rueda *et al.*, 2004).

Problematic attention is a common symptom of autism spectrum disorder. The individuals with ASD demonstrated increased rates of error in executive control and alerting networks and reduced activity in the mid-frontal gyrus for alerting and lack of activation in cingulate cortex for executive control (Fan *et al.,* 2012). Another study discovered that children having ADHD showed poor executive functioning, but high orienting responses as compared to normal individuals. Normal individuals show less efficiency in executive control as compared to those with high anxiety, but no deficiency showed in alerting and orienting networks (Mogg *et al.,* 2015). A study conducted to find the impact of trait anxiety on different components of attention concluded that individuals high in trait anxiety showed less efficiency in executive control trials (Pacheco-Unguetti *et al.,* 2010).

3. Research Method

3.1 Participant's Characteristics

The sample size was determined using statistical power analysis (G* power). The data was collected from 56 on-campus psychology students (12 males and 44 females; age: 19-28 years). The participants were selected through initial screening on a state-trait anxiety test (Spielberger et al., 1983). Half of the participants who scored 45 to 80 participated in group of high-trait anxiety and the other half who scored 20 to 37 on the scale participated in group of low-trait anxiety. Their eyesight was normal or near to normal. The participants filled in the informed consent before the task.

3.2 Procedure

The study was conducted by following the ethical guidelines of APA. It was a mixed-design experiment with high and low trait anxiety studied between groups and orienting, congruent, and alerting within the group. The purposive sampling technique was used.

Throughout the experiment, the participant was instructed to maintain a fixed gaze on screen of the laptop while wearing headphones to hear the alert tone. The participants were requested to keep their mobile phones silent or turn them off to avoid any interruption. Then, they performed the ANTI-Vea task.

Standard keyboards were used to enter responses. Five black arrows, each measuring 50 pixels wide by 23 pixels high and pointing either left or right, were employed as stimuli, together with a black asterisk, warning tone, and fixation cross. Each arrow was 63 pixels apart from the next arrow on the horizontal axis. In EV trials, the central arrow is slightly displaced at 8 PX either upward or downward. In arousal vigilance measurement, a red MS count down (110 pixels height for each number) was shown on and off at fixation. After completing the task, participants filled out an anxiety scale to ensure that they were placed in the appropriate group.

3.3 Instruments

3.3.1 State-Trait Inventory of Anxiety

This measure was developed by Spielberger (1983). It is a highly reliable tool to measure state-trait anxiety for research and clinical practices. It contains 2 subscales with 20 items each, the S-Anxiety subscale to measure anxiety's emotional state, and T-Anxiety to measure general anxiety as a personality trait.

Participants filled out the 20 items questionnaire about their general feelings of anxiety-related thoughts on a 4-point rating scale while answering the trait questions. The rating scale ranges from almost never (1) to almost always (4). The items include both negative and positive

statements. The sum of the 20 items' scores, some of which had their scores reversed, is used to get the final score. There could be a range of 20 to 80. Higher scores suggest greater trait anxiety.

3.3.2 Attention Network Task with Interaction – Vigilance (executive/arousal)

The attention network test is a computer-based test designed to measure the 3 different components of attention. The flanker paradigm and the cuing task are combined in it. Based on Posner's neurocognitive model of the human attention system (1994), it was created by Fan and his colleagues in (2002). The ANTI-Vea task is slightly different from the original version of the task, it measures interaction between three attentional networks with vigilance of executive and arousal. Three different types of trials are included in ANTI-Vea, and they are presented in a session of an experiment in random order: (1) ANTI trials, comprise 60% of experiment, assess the interactions and effects of three attentional networks; (2) EV trials, comprise 20% of experiment, assess signal detection; and (3) AV trials, comprise 20% of experiment.

Initially, the participants do the trials of practice, which comprise 16 ANTI trials, then 32 EV and ANTI trials, and finally 48 AV, EV, and ANTI trials followed by the feedback. Then, they had to complete the 40 random trials comprised of 8 EV, 8 AV, and 24 ANTI trials with no feedback.

In trials of ANTI, the fixation point having plus sign for 400 MS to 1600 MS was displayed on the computer screen. Additionally, a target stimulus comprising of an arrow that may point left or right was displayed in the ANTI trials after fifty MS and was surrounded by 4 additional arrows, 2 on each side. Congruent trials involved the flanking arrows pointing in the same direction as the central target arrow, or incongruent trials to the opposite direction. For indicating the target's direction, participants had to press one of the two keys, C for the center arrow's left direction and M for the center arrow's right direction (either left or right). These incongruent and congruent conditions are used to measure executive control.

To measure phasic alertness, an alerting tone condition was presented for half of the trials, and in the remaining half, no alerting tone was used. After 400 MS, an asterik visual signal was presented for approximately 50 MS, either above (for 1/3) or below (for 1/3) the point of fixation. There was no asterisk displayed for the remaining one-third of the trials. If the asterik was on same side of arrow it was valid cue condition, if it was on the opposite side of arrow it was invalid and no arrow means no cue. It measured orienting network. Then, the asterik disappeared and left only the point of fixation.

During EV, the whole process was the same as in ANTI apart from the slight displacement of the middle arrow (8 PX) either upside or downside. The participant had to press the spacebar on the computer each time the arrow moved from its position. The participants were told to maintain vigilance in case of any displacement. In the AV trials, a red MS down counter from 1000 - 0 appeared on the screen. To stop this countdown, the participant had to quickly press any key on the keyboard. The participant pressed any key on the keyboard whenever the countdown appeared on the screen.

Finally, the experiment started, and without any pause or feedback, participants completed the task. The experiment consists of 4 blocks, each of which has 80 random trials divided into 16 EV, 16 AV, and 48 ANTI trials.

3.3.3 Data Analysis

The inclusion criteria were the completion of all 4 blocks, hence only 1 participant performed fewer than 4 blocks and was excluded from the data analysis. After that, eliminated all

the outliers if any from the study. Outliers were defined as participants in ANTI trials with RT 0.25 SD and 75% accuracy. Three outliers in the group of high-trait anxiety and two outliers in the group of low-trait anxiety founded and were excluded.

The three separate repeated measure ANOVA was performed. Trait anxiety levels were between-group, whereas warning signals (with tone/ without tone), visual cues (invalid cued/cued/no cued), and executive control (congruent/incongruent) were within the group in 1st analysis of ANOVA. The dependent variables, however, were reaction time and error percentage. Trait anxiety levels were between group factors, participant performance on 4 blocks was within factor and sensitivity, response bias; hits; and false alarms were dependent variables in 2nd analysis of ANOVA. Trait anxiety levels were between group factors, participant performance on 4 blocks were within factor and ST of reaction time, mean RT, and lapses % were dependent variable in 3rd analysis of ANOVA.

4. Results

For data analysis, IBM SPSS version 23 was employed. The performance of participants was investigated under two distinct experimental settings using a repeated measure mixed model ANOVA. The two levels of trait anxiety were the experimental conditions.

Table 1.

Mean, SD (in parentheses) for error % (accuracy), and RT in high / low trait anxiety groups for ANTI with warning signal, visual cue, executive control.

No Alerting Tone					**Alerting Tone**		
		Invalid	**No cue**	**Valid**	**Invalid**	**No cue**	**Valid**
RT							
High Trait	Congruency	.068 (.1170)	.068 (.1059)	.096 (.2265)	.063 (.1045)	.003 (.0145)	.058 (.1174)
	Incongruency	.118 (.2178)	.058 (.0271)	.060 (.1004)	.076 (.2082)	.036 (0763)	.041 (.0786)
Low Trait	Congruency	.061 (.0791)	.052 (.0509)	.070 (.0945)	.043 (.0667)	.036 (.0515)	.070 (.0946)
	Incongruency	.082 (.0904)	.079 (.0791)	.072 (.0699)	.065 (.0840)	.040 (.0527)	.031 (.0539)
Accuracy							
High Trait	Congruency	.072 (.1141)	.115 (.1356)	.059 (.1215)	.065 (.1059)	.003 (.0148)	.055 (.0823)
	Incongruency	.107 (.1339)	.016 (.0498)	.067 (.0983)	.041 (.0709)	.043 (.0786)	.056 (.1171)
Low Trait	Congruency	.071 (.0982)	.070 (.0754)	.075 (.1013)	.045 (.0685)	.042 (.0601)	.073 (.0987)
	Incongruency	.084 (.0890)	.084 (.0821)	.089 (.0741)	.079 (.0918)	.044 (.0505)	.041 (.0565)

Note: RT in MS, in parentheses, is ST.

Figure 1

Warning signals, visual cues, and executive control in RT (MS) in the high/low anxiety groups are graphically represented.

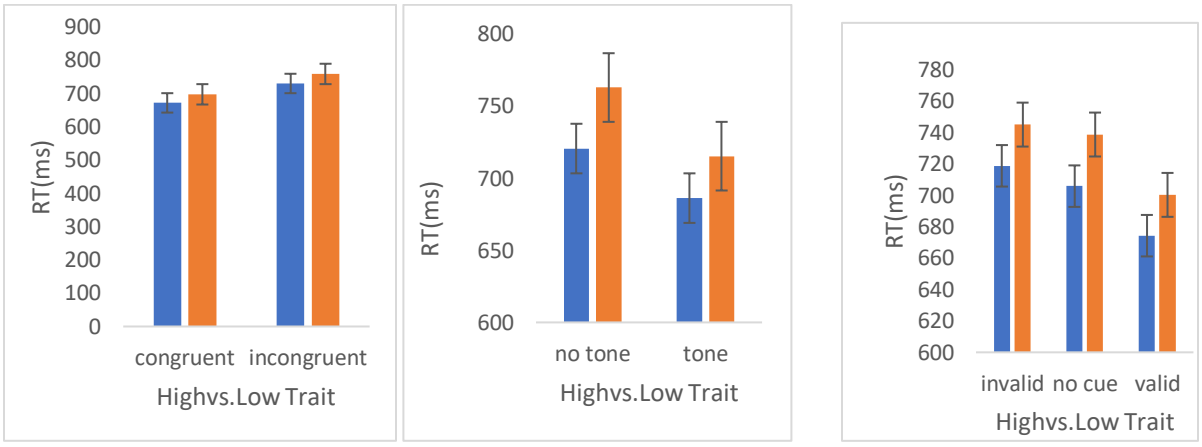


Figure 2

Warning signals, visual cues, and executive control in % of error in high/ low anxiety groups are graphically represented.

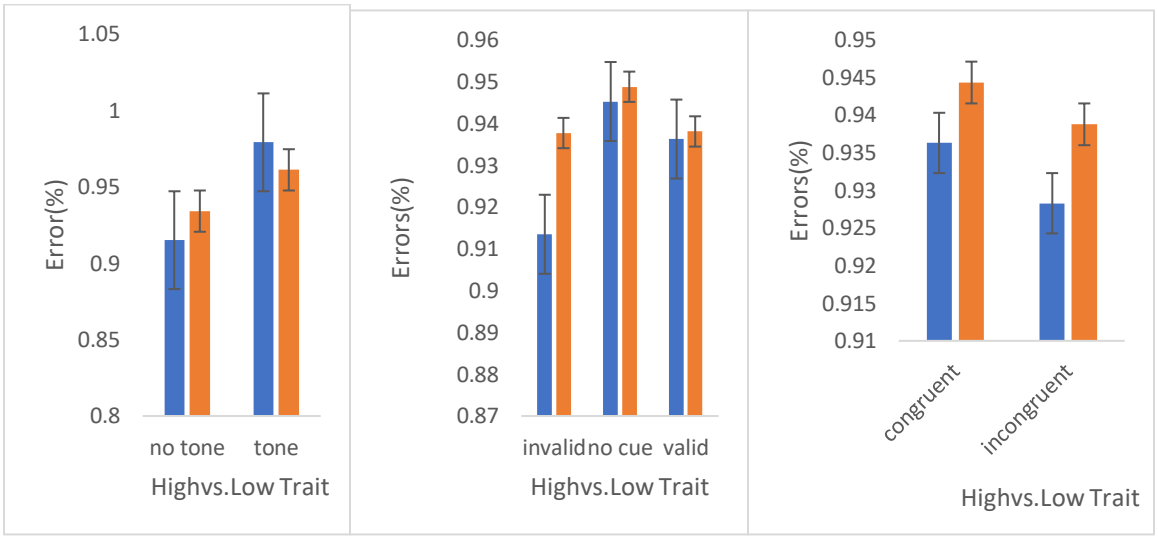
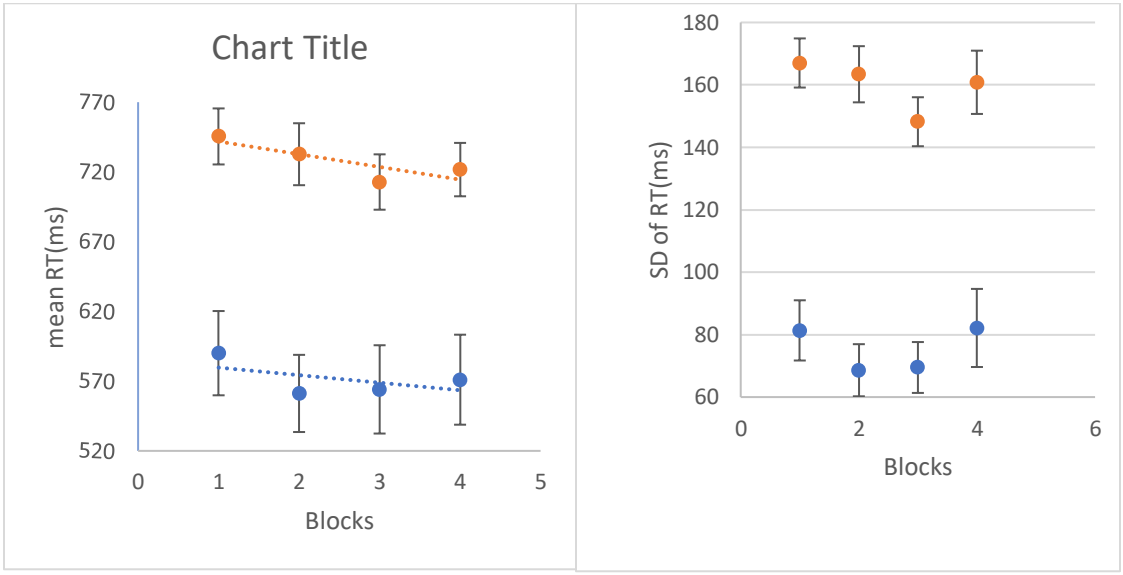


Figure 3

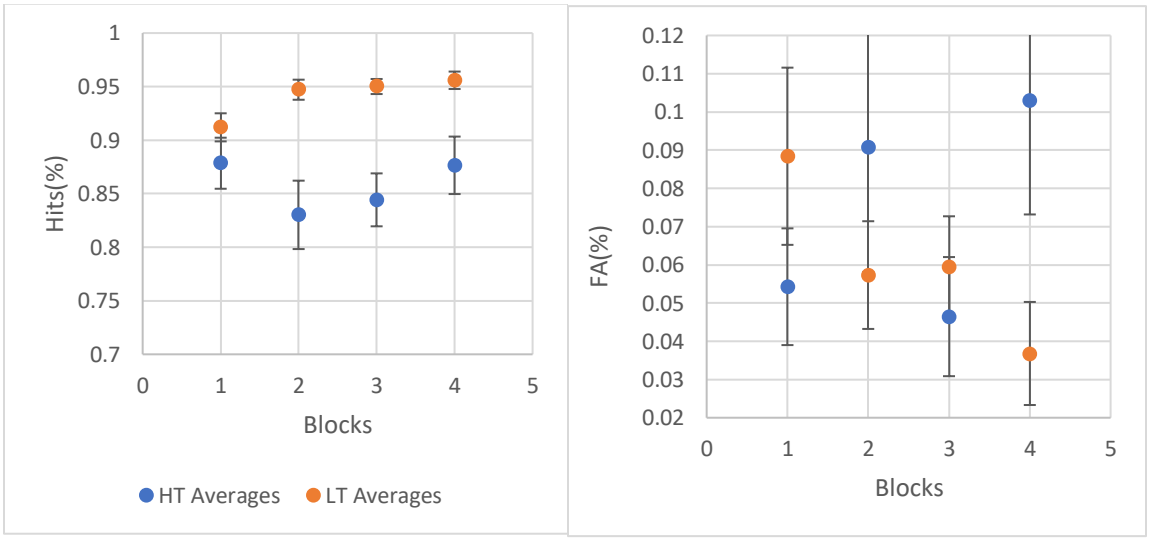
Mean RT and SD of RT on AV in high/ low Anxiety groups are graphically represented.



Note. SD of Reaction Time, arousal vigilance, RT (reaction time)

Figure 4

Hits, FA on EV in high/ low groups are graphically represented.



Note. EV (executive vigilance), FA (false alarm)

5. Discussion

Nowadays, researchers taking great interest in measuring the vigilance decrement phenomenon. It was assessed through ANTI-Vea developed by Luna et al. (2018). In the past, the ANTI task was used to examine the impact of trait anxiety on attentional networks (Pacheco-Unguetti *et al.,* 2010). But its effect was not previously measured with vigilance. That's why the

present study planned to measure the impact of trait anxiety on attention as well as on vigilance (executive and arousal).

It was reported that low and high-trait anxiety groups performed faster in alerting tones than that in without alerting tones, so a significant effect of warning signals was found within the group condition. The findings are consistent with previous research (Posner *et al.,* 2020). As predicted, trait anxiety groups will perform faster in valid cued conditions than no cued and invalid cued. This hypothesis was accepted. Also, the results concur with previous findings (Posner, 2016; Luna *et al.,* 2020). It was hypothesized that both groups will likely perform faster in congruent conditions than in incongruent conditions, both groups performed the same in congruent vs. incongruent conditions. The hypothesis was rejected.

It was hypothesized that anxiety groups will perform with more accuracy in tone conditions than without alerting tone. However, outcomes revealed that both groups performed more accurately when there was no alarm tone, the hypothesis was rejected. Moreover, the hypothesis assumed that participants would perform accurately in valid cued conditions, is rejected. Because the high trait group performed accurately in invalid cued conditions as opposed to valid and no cued.

It was predicted that low anxiety groups will perform faster in alerting, orienting, and executive control than high anxiety groups. However, the outcomes showed that high anxiety groups outperformed low anxiety groups in between group conditions in alerting tone and valid cued conditions. The hypothesis was rejected. The results revealed that the high anxiety participants performed more accurately in the absence of tone, incongruent and invalid cued than the low anxiety group in between group conditions. The hypothesis was rejected.

The mean and SD of RT in arousal vigilance differ among the high-anxiety and low-anxiety groups. When compared to the low anxiety group, the high anxiety group responds more quickly and has a smaller RT and SD of RT. Between the two groups, a significant difference was discovered between Hits and sensitivity. The high trait group exhibit slightly higher Hits and A' scores, so the hypothesis was rejected. Regarding EV, only FA exhibits a significant difference within the group, indicating a little decline in FA across blocks.

The hypothesis that a reduction in arousal vigilance would result in an increment in reaction time was rejected. While the low-trait group didn't respond to lapses, the high-trait group showed responses. While both groups not exhibit an increment in response time over blocks. However, due to the third block's quicker response time, the SD of RT revealed a significant difference within the group condition. As was hypothesized executive decrement would cause response biasness increment. But it was not noted in the present study. The hypothesis was rejected.

6. Conclusion

Thus, it can be concluded that as compared to individuals with high trait anxiety, alerting and orienting networks of individuals with low trait anxiety are less efficient. Both groups showed results in orienting and alerting networks of attention and the interaction was observed between them. The outcomes of our study may potentially be affected by a few other factors. Much research which used the ANTI-Vea was carried out in Spain, and other civilized countries. It was the first experimental research carried out in Pakistan to test the impact of anxiety on attention using ANTI-Vea. It demonstrated original findings of its kind. People in this region have diverse

personalities, diets, and levels of mentality. They experienced different circumstances in life. Additionally, the issues with the economy differ from those in emerging nations. They also dealt with issues like terrorism, suicide bombing, etc. in previous years. Additionally, as the people are Muslims, they fully believed in Allah in both good and bad circumstances. Therefore, we may conclude that Pakistanis can maintain good attention even in stressful situations and do not exhibit a decline in executive or arousal vigilance.

7. Limitations and suggestions

Despite the interaction shown in attentional networks, this research has certain limitations. The vigilance decrement was not observed in the present study which was an important variable to be studied. The reason behind the absence of vigilance decrement may be the use of 4 blocks of trials in the present study. However, there was evidence of the usage of 4 blocks in a prior study, and there was a decline in vigilance (Román- Caballero *et al.,* 2020). Additionally, it was stated in the online ANTI-Vea task template that the task would be considered complete if the participant completed at least 80 trials in the first four blocks. Except for one individual who was not included in the analysis, all participants met this requirement. We used 4 blocks in our study because there were also practice blocks before the experiment and the task itself was rather time-consuming, we employed 4 blocks in our study. Given the length of the entire process, it was decided to use 4 blocks in this study. The present study gives empirical evidence that only completing 4 blocks is insufficient for measuring the decrement in vigilance, which is a crucial aspect of this experiment. Therefore, to demonstrate a decrement in vigilance, future research should be planned to finish at least 5 or 6 blocks altogether. Moreover, the research was conducted on university students. University students could not experience anxiety at such a level as the individual experiences it in practical life, so future researchers shall plan to include adult participants in their study.

References

Brunye, T. T., Mahoney, C. R., Lieberman, H. R., & Taylor, H. A. (2010). Caffeine modulates attention network function. *Brain and Cognition, 72*(2), 181–188.

Callejas, A., Lupiáñez, J., & Tudela, P. (2004). The three attentional networks: On their independence and interactions. *Brain and cognition, 54*(3), 225–227.

Caumo, W., Broenstrub, J. C., Fialho, L., Petry, S. M. G., Brathwait, O., Bandeira, D., ... & Ferreira, M. B. C. (2000). Risk factors for postoperative anxiety in children. *Acta aSnaesthesiologica scandinavica, 44*(7), 782-789.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. . (2007). Anxiety and cognitive performance: attentional control theory. *Emotion, 7*(2), 336.

Fan, J., Bernardi, S., Van Dam, N. T., Anagnostou, E., Gu, X., Martin, L., ... & Grodberg, D. . (2012). Functional deficits of the attentional networks in autism. *Brain and behavior, 2*(5), 647–660.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of cognitive neuroscience, 14*(3), 340–347.

Helton, W. S., Hollander, T. D., Warm, J. S., Tripp, L. D., Parsons, K., Matthews, G., ...& Hancock, P. A. . (2007). The abbreviated vigilance task and cerebral hemodynamics. *Journal of Clinical and Experimental Neuropsychology, 29*(5), 545-552.

Ishigami, Y., Eskes, G. A., Tyndall, A. V., Longman, R. S., Drogos, L. L., & Poulin, M. J. (2016). The Attention Network Test-Interaction (ANT-I): reliability and validity in healthy older adults. *Experimental Brain Research, 234*(3), 815-827.

James, W. (2007). *The principles of psychology.* (Vol. 1)Cosimo, Inc.

Koster, E. H., Crombez, G., Vershuere, B., Van Damme, S., & Wiersema, J. R. (2006). Components of attentional bias to threat in high trait anxiety: Facilitated engagement, impaired disengagement, and attentional avoidance. *Behaviour Research and therapy, 44*(12), 1757-1771.

Langner, R., Eickhoff, S.B., (2013). Sustaining attention to simple tasks: A meta-analytic review of the neural mechanisms of vigilant attention. *Psychol. Bull.*, 139, 870– 900. https://doi.org/10.1037/a0030694.

Luna, F. G., Barttfeld, P., Martín Arévalo, E., & Lupiáñez Castillo, J. (2021). The ANTI-Vea task: Analyzing the executive and arousal vigilance decrements while measuring the three attentional networks.

Luna, F. G., Marino, J., Roca, J., & Lupiáñez, J. (2018). Executive and arousal vigilance decrement in the context of the attentional networks: The ANTI-Vea task. *Journal of Neuroscience Methods, 306*, 77–87.

Luna, F. G., Roca, J., Martín-Arévalo, E., & Lupiáñez, J. . (2020). Measuring attention and vigilance in the laboratory vs. online: The split-half reliability of the ANTI-Vea. . *Behavior Research Methods*, 1-24.

Martella, D., Casagrande, M., & Lupiáñez, J. (2011). Alerting, orienting and executive control: The effects of sleep deprivation on attentional networks. *Experimenta Brain Research, 210*(1), 81–89.

Mogg, K., Salum, G. A., Bradley, B. P., Gadelha, A., Pan, P., Alvarenga, P., ... & Manfro, G. G. . (2015). Attention network functioning in Attention network functioning in children with anxiety disorders, attention-deficit/hyperactivity disorder and non-clinical anxiety. *Psychological medicine, 45*(12), 2633.

Oken, B.S., Salinsky, M.C., Elsas, S.M.,. (2006). Vigilances, alertness, or sustained attention: physiological basis and measurement. *Clin. Neurophysiol.*, 117, 1885– 1901. https://doi.org/10.1016/j.clinph.2006.01.017.

Pacheco-Unguetti, A. P., Acosta, A., Callejas, A., & Lupiáñez, J. (2010). Attention and anxiety: Different attentional functioning under state and trait anxiety. *Psychological science*, *21*(2), 298–304.

Petersen, S. E., & Posner, M. I. (2012). The Attention System of the Human Brain: 20 Years After. *Annual review of neuroscience, 35*, 73–89.

Posner, M. I. (1994). Attention: The mechanism of consciousness. *Proceedings of the National Academy of Sciences*, *91*(16), 7398–7402.

Posner, M. I. (2008). Measuring alertness. *Annals of the New York Academy of Sciences, 1129*(1), 193-199.

Posner, M. I. (2016). Orienting of attention: Then and now. *Quarterly journal of experimental psychology, 69*(10), 1864-1875.

Roca, J., Castro, C., López-Ramón, M. F., & Lupiáñez, J. (2011). Measuring vigilance while assessing the functioning of the three attentional networks: the ANTI-Vigilance task. *Journal of Neuroscience Methods, 198*(2), 312–324.

Roca, J., García-Fernández, P., Castro, C., & Lupiáñez, J. (2018). The moderating effects of vigilance on other components of attentional functioning. *Journal of Neuroscience Methods, 308*, 151–161.

Román-Caballero, R., Martín-Arévalo, E., & Lupiáñez, J. . (2020). Attentional networks functioning and vigilance in expert musicians and non-musicians. *Psychological research*, 1-15.

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Pappert Lecari, L., & Posner, M. I. (2004). Development of attentional networks in childhood. *Neuropsychologia, 42*(8), 1029–1040.

Shenhav, A., Botvinick, M.M., Cohen, J.D.,. (2013). The expected value of control: an integrative theory of anterior cingulate cortex function. *Neuron*, 79, 217–40. https://doi.org/10.1016/j.neuron.2013.07.007.

Spilberger, D. C. (1983). Manual for the State-Trait Anxiety Inventory (Form Y): self-evaluation questionnaire. *Consulting Psychologists, Press, California*, 1-36.

Spielberger, C. D. (2013). Anxiety: Current trends in theory and research. *Elsevier*.

Walsh, J. J., Balint, M. G., SJ, D. R. S., Fredericksen, L. K., & Madsen, S. (2009). Predicting individual differences in mindfulness: The role of trait anxiety, attachment anxiety and attentional control. *Personality and individual differences, 46*(2), 94-99.

Warm, J. S., Parasuraman, R., & Matthews, G. . (2008). Vigilance requires hard mental work and is stressful. *Human factors, 50*(3), 433–441.