

# Behavior characteristics of the attention network of military personnel with high and low trait anxiety

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## Abstract

Converging evidence reveals significant increase in both state anxiety and trait anxiety during the past 2 decades among military servicemen and servicewomen in China. In the present study, we employed the Chinese version of the State-trait Anxiety Inventory (STAI) to examine trait and state anxiety in Chinese military servicemen and servicewomen. We further evaluated orienting, alerting and execution inhibition using the attention network test.

Healthy military servicemen and servicewomen were recruited for the present study. The STAI was used to measure both state and trait anxiety and the attention network test was done to determine reaction time and accuracy rate.

Fifty-seven subjects were eligible for the study. Their mean STAI score was  $3.2 \pm 2.8$  (range, 1–17) and 29 (50.9%) subjects were categorized into the high trait anxiety group and 28 (49.1%) subjects into the low trait anxiety group. The reaction time of the high trait anxiety group to incongruent, congruent, and neutral target was significantly longer than that of the low trait anxiety group ( $P < .05$ ). Moreover, the accurate rate of the high trait anxiety group for incongruent, congruent, and neutral target was significantly higher than that of the low trait anxiety group ( $P < .05$ ). Repeated analysis of variance showed marked effect of trait anxiety, cue types, and target types on reaction time. There was significant interaction among trait anxiety, target types, and cue types. Trait anxiety and target types also had marked effect on the accurate rate. Multivariate analysis showed no marked effect of trait anxiety on the alerting, orienting, and execution inhibition subnetwork.

The present study has demonstrated that military service personnel with high trait anxiety requires more time for cognitive processing of external information but exhibits enhanced reaction accuracy rate compared to those with low trait anxiety. Our findings indicate that interventional strategies to improve the psychological wellbeing of military service personnel should be implemented to improve combat mission performance.

**Abbreviations:** ANOVA = analysis of variance, RT = reaction time, STAI = state-trait anxiety inventory.

**Keywords:** attention network test, state-trait anxiety inventory, trait anxiety

## 1. Introduction

Although anxiety is considered a negative emotional response to threatening circumstances, it is also an adaptive mechanism and

confers a survival value by enabling a quick and accurate detection of a potential threatening stimulus or situation. Trait anxiety represents the propensity of an individual to be anxious,<sup>[1]</sup> reflecting individual differences in sensitivity to negative or threatening stimulus, whereas state anxiety represents current transient anxiety level. Studies on anxiety have mostly focused on influence of anxiety on higher cognitive processes such as cognitive performances. It has been found that individuals with high trait anxiety exhibit impaired inhibitory learning of the threat cue<sup>[2]</sup> and performance of prefrontal-dependent cognitive control tasks.<sup>[3]</sup>

Evidence suggests a link between trait anxiety and altered functioning, including threat-related changes in selective attention to emotionally aversive stimuli. Presently, it remains unclear how in complex stressful situations trait anxiety affects the engagement of individuals in selective attention and executive functioning. Military servicemen and servicewomen are faced with stressful circumstances to a far greater extent than civilians. In modern warfare, military servicemen and servicewomen not only have to tackle with the pressure of close distance combat but also have to be prepared against distant attacks. This perpetual uncertainty exerts continuous pressure on the combatants, causing stressful responses. It has been noted that military servicemen and servicewomen with high trait anxiety are more prone to development of state anxiety, which compromises their combat capacity and may lead to aberrant behaviors such as desertion, self-mutilation, and suicide. A recent meta-analysis of 18,106 military personnel for state anxiety and 21,047 military

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personnel for trait anxiety showed significant increase in both state anxiety and trait anxiety during the past 2 decades among military servicemen and servicewomen in China,<sup>[4]</sup> highlighting a critical challenge for combat performance and for mental healthcare for military personnel.

Posner and Petersen proposed a hypothetical attention network, which is a selective attention system composed functionally and anatomically of 3 independent neural network modules, each responsible for orienting, alerting, or executive control.<sup>[5]</sup> Fan et al<sup>[6–9]</sup> evaluated the 3 subnetworks of the selective attention network by using the attention network test. In the present study, we employed the Chinese version of the State-trait Anxiety Inventory (STAI), which is widely used to assess anxiety and can differentiate anxiety into state and trait anxiety, to examine trait and state anxiety in Chinese military servicemen and servicewomen. We further evaluated orienting, alerting, and execution inhibition using the attention network test developed by Fan et al.

## 2. Subjects and methods

### 2.1. Subjects

We prospectively recruited healthy military personnel for the present study. The following inclusion criteria were used for eligibility for the study: age between 18 and 30 years; right hand dominance; normal visual acuity after correction. Major exclusion criteria were as follows: mental disabilities according to DSM-V or neurocognitive impairment; history of use of psychotic substances; severe somatic diseases. The study protocol was approved by the local institutional review board at the authors' affiliated institution and all the study participants provided written informed consent.

### 2.2. STAI

The STAI is a self-reported measure of both state and trait anxiety with 20 items in each domain. The STAI has been validated in Chinese population<sup>[10]</sup> with good validity and internal consistency (Cronbach  $\alpha > 0.87$  and test-retest reliability  $\geq 0.78$ ).<sup>[11]</sup> Higher STAI scores indicate greater anxiety. Subjects with STAI scores in the top 25<sup>th</sup> percentile were categorized into the high trait anxiety group and those with STAI scores in the bottom 25<sup>th</sup> percentile were categorized into the low anxiety group according to trait anxiety scores.

### 2.3. Attention network test

Attention network test was done as described by Fan et al. It included 4 cues and 3 targets and was accomplished using the keyboard of computers and 2 reaction keys. Subjects were allowed to familiarize with the test before taking the formal test. The eye to screen distance was 60 cm; the plus sign (+) was located in the center of the screen as the focus of attention, and stimuli appeared superior or inferior to the plus sign in the form of an asterisk (\*) as interference signals or in the form of directional arrowheads ( $\rightarrow$  or  $\leftarrow$ ) as target signals. Inference signals may appear in the center of the screen (central cue), superior and inferior to the center simultaneously (double cues) or separately (spatial cue) or does not appear (no cue). Target signals may appear in the form of a single arrowhead (neutral target), 50 ispidirectional arrowheads in 1 row with the center arrowhead as the congruent target, or the center arrowhead contradi-

rectional target. Subjects were asked to promptly identify the direction of the target signal and alerting to attention network; orienting and reaction time (RT) and accuracy rate were recorded in the computer. The effectiveness of the 3 attention subnetworks was calculated as: alerting network =  $RT_{no\ cue} - RT_{double\ cues}$ , with higher values indicating more potent alerting network, orienting network =  $RT_{central\ cue} - RT_{space\ cue}$ , with higher values indicating a more potent network, and execution network =  $RT_{incongruent\ cues} - RT_{congruent\ cues}$ , with lower values indicating a more potent network. Mean reaction time was equal to total key press time/360, and accuracy rate was equal to (total number of reactions – number of wrong hits)/total number of hits  $\times 100\%$ .

### 2.4. Statistical analysis

Data were expressed mean  $\pm$  standard deviation and analyzed using the SAS9.3 software (SAS Institute, Cary, NC). Univariate analysis was carried out according to reaction time to targets and comparison between 2 groups was made using the SNK method. Multivariate analysis was performed by block and group of reaction accuracy rate and reaction time. Block and group were as follows: group (high and low trait anxiety)  $\times$  time (3 repeat blocks)  $\times$  cue types (no cues, central cues, double cues, and spatial cues)  $\times$  target types (neutral, congruent, and incongruent). Two side tests were used and  $P$  value  $< .05$  was considered statistically significant.

## 3. Results

### 3.1. Demographic and baseline characteristics of the study subjects

One hundred twenty-three subjects including 4 females were evaluated for inclusion in the study. Sixty-three subjects were excluded because their STAI scores were in the 26<sup>th</sup> to 74<sup>th</sup> percentile and 3 subjects were excluded because they had an accuracy rate  $< 75\%$ . Finally, 57 subjects were eligible for the study. Their mean age was  $21.6 \pm 3.03$  (range, 17–35) years, with a mean duration of military service of  $3.2 \pm 2.8$  (range, 1–17) years. Their mean STAI score was  $41.8 \pm 8.2$  and 29 (24.2%, 29/120) subjects were categorized into the high trait anxiety group and 28 (23.3%, 28/120) subjects into the low trait anxiety group. The 2 groups were comparable in demographic and baseline characteristics including age, duration of military service, and STAI scores ( $P > .05$ ).

### 3.2. Reaction time and accuracy

The reaction time to no cues was the longest for all 3 types of target (congruent, incongruent, and neutral), followed by central cues and double cues for congruent and neutral cues and then spatial cues for all 3 types of target (Table 1). Statistically significant difference in reaction time was noted among the groups ( $P < .05$ ). The reaction time of the high trait anxiety group ( $566 \pm 111.30$  ms) was significantly longer than that of the low trait anxiety group ( $536.90 \pm 99.13$  ms) ( $P < .01$ ). The reaction time of the high trait anxiety group to incongruent, congruent, and neutral target was significantly longer than that of the low trait anxiety group ( $P < .05$ ) (Table 1).

Furthermore, we observed no statistically significant difference in the reaction accuracy rate for the 4 cue types in either the high or low anxiety group (Table 2) ( $P > .05$ ). Moreover, the accurate rate of the high trait anxiety group ( $0.97 \pm 0.10\%$ ) was markedly

**Table 1**  
**Reaction time (ms) of the high and low trait anxiety groups for different cue types.**

Target	Cue type			
	Center cue	Double cues	No cue	Spatial cue
Congruent				
Low trait anxiety	492.934 ± 69.554 <sup>*,†,‡,§</sup>	491.870 ± 62.816 <sup>†,‡,§,  </sup>	525.468 ± 81.278 <sup>*,‡,§,  </sup>	460.388 ± 65.040 <sup>*,†,§,  </sup>
High trait anxiety	536.538 ± 99.641 <sup>*,†,‡</sup>	513.170 ± 77.458 <sup>†,‡,  </sup>	560.356 ± 99.232 <sup>*,‡,  </sup>	501.802 ± 100.503 <sup>*,†,  </sup>
Incongruent				
Low trait anxiety	617.975 ± 92.538 <sup>*,†,‡,§</sup>	618.440 ± 98.979 <sup>†,‡,§,  </sup>	630.326 ± 88.487 <sup>*,‡,§,  </sup>	591.150 ± 128.531 <sup>*,†,§,  </sup>
High trait anxiety	633.206 ± 102.010 <sup>*,†,‡</sup>	650.886 ± 120.831 <sup>†,‡,  </sup>	665.555 ± 119.699 <sup>*,‡,  </sup>	621.794 ± 193.969 <sup>*,†,  </sup>
Neutral				
Low trait anxiety	496.971 ± 69.643 <sup>*,†,‡,§</sup>	486.317 ± 51.580 <sup>†,‡,§,  </sup>	523.497 ± 88.737 <sup>*,‡,§,  </sup>	468.322 ± 60.324 <sup>*,†,§,  </sup>
High trait anxiety	541.261 ± 92.901 <sup>*,†,‡</sup>	530.972 ± 89.076 <sup>†,‡,  </sup>	555.879 ± 92.953 <sup>*,‡,  </sup>	503.275 ± 77.452 <sup>*,†,  </sup>

|| Compared with center cue, *P* < .05.  
 \* Compared with double cues, *P* < .05.  
 † Compared with no cue, *P* < .05.  
 ‡ Compared with spatial cue, *P* < .05.  
 § Compared with high trait anxiety, *P* < .05.

higher than that of the low trait anxiety group (0.95 ± 0.13%) (*P* < .05). The accurate rate of the high trait anxiety group for incongruent, congruent, and neutral target was significantly higher than that of the low trait anxiety group, respectively (*P* < .05) (Table 2).

**3.3. Interaction among reaction time and other parameters**

Repeated analysis of variance (ANOVA) showed marked effect of trait anxiety on reaction time (F[1, 674]Y=Y20.85, *P* < .0001), indicating that trait anxiety exerted significant effect on reaction time in attention network (Table 3). Cue types also had significant effect on reaction time (F[3, 674]Y=Y17.06, *P* < .0001), and target types had marked effects on reaction time (F[2, 674]Y=Y129.77, *P* < .0001). However, no marked interaction was observed between trait anxiety and target types (F[2, 674]=0.11, *P* = .8969], between trait anxiety and cue types (F[3, 674]=0.07, *P* = .9751), between cue types and target types (F[6, 674]=0.13, *P* = .9922), and between trait anxiety and repeat blocks (F[2, 674]Y=1.18, *P* = .3071). However, we found significant interaction among trait anxiety, target types, and cue types (F[6, 674]Y=Y0.01, *P* = 1.0000). We also found significant interaction between trait anxiety and repeat block (F[2, 674]Y=Y3.49, *P* = .0310), and between target types and repeat blocks (F[4, 674]Y=Y2.55, *P* = .0384). By contrast, we found no marked interaction among trait anxiety, repeat blocks,

and target types [F(4, 674)=0.56, *P* = .6946], between repeat block and cue types (F[6, 674]Y=1.09, *P* = .3697), among trait anxiety, repeat block, and cue types (F[6, 674]Y=Y0.87, *P* = .5133), among repeat blocks, target types, and cue types (F[12, 674]=0.65, *P* = .7978) and among trait anxiety, repeat blocks, target types, and cue types (F[12, 674]Y=Y0.87, *P* = .5819). 509 Windy Peak Loop, Cary, NC 27519 509 Windy Peak Loop, Cary, NC 27519

**3.4. Interaction among reaction accuracy rate and other parameters**

We further analyzed the interaction among reaction accuracy rate and other parameters. Repeated ANOVA showed marked effect of trait anxiety on the accurate rate (F[1, 674]Y=Y5.90, *P* = .0154) (Table 4), indicating that trait anxiety exerted significant effect on the accurate rate of reaction in attention network. Moreover, 3 repeat blocks had marked effect on the accurate rate (F[2, 674]=8.27, *P* = .0003), whereas cue types had no significant effect on the accurate rate (F[3, 674]=0.39, *P* = 7602). Target types also had marked effect on the accurate rate (F[2, 674]=36.72, *P* < .0001), but there was no significant interaction between trait anxiety and target types (F[2, 674]=0.23, *P* = .7968), between trait anxiety and cue types (F[3, 674]Y=0.07, *P* = .9751), between cue types and target types (F[6, 674]Y=Y0.18, *P* = .9829), and among trait anxiety, target types, and cue types (F[6,674]Y=Y0.12, *P* = .9941). By contrast, there

**Table 2**  
**The accuracy rate of the high and low trait anxiety group for different cue types.**

Target	Cue types			
	Center cue	Double cues	No cue	Spatial cue
Congruent	0.966 ± 0.109 <sup>*</sup>	0.976 ± 0.100 <sup>*</sup>	0.971 ± 0.108 <sup>*</sup>	0.966 ± 0.109 <sup>*</sup>
Low trait anxiety	0.992 ± 0.030	1.000 ± 0.000	1.000 ± 1.000	0.989 ± 0.036
High trait anxiety				
Incongruent	0.901 ± 0.143 <sup>*</sup>	0.901 ± 0.165 <sup>*</sup>	0.865 ± 0.169 <sup>*</sup>	0.890 ± 0.205 <sup>*</sup>
Low trait anxiety				
High trait anxiety	0.891 ± 0.225	0.871 ± 0.213	0.895 ± 0.217	0.927 ± 0.190
Neutral	0.981 ± 0.098 <sup>*</sup>	0.976 ± 0.100 <sup>*</sup>	0.976 ± 0.100 <sup>*</sup>	0.981 ± 0.098 <sup>*</sup>
Low trait anxiety				
High trait anxiety	0.992 ± 0.030	0.985 ± 0.041	0.989 ± 0.036	0.992 ± 0.030

\* Compared with high trait anxiety, *P* < .05.

**Table 3****Multivariate analysis of determinants of reaction time.**

Effect	Freedom of numerator	Freedom of denominator	F	P
Group	1	674	20.85	<.0001
Target	2	674	129.77	<.0001
Group*target	2	674	0.11	.8969
Cues	3	674	17.06	<.0001
Group*cues	3	674	0.07	.9751
Target*cues	6	674	0.13	.9922
Group*target*cues	6	674	0.01	1.0000
Time	2	674	1.18	.3071
Group*time	2	674	3.49	.0310
Time*target	4	674	2.55	.0384
Group*time*target	4	674	0.56	.6946
Time*cues	6	674	1.09	.3697
Group*time*cues	6	674	0.87	.5133
Time*target*cues	12	674	0.65	.7978
Group*time*target*cues	12	674	0.87	.5819

was a significant interaction between trait anxiety and repeat block ( $F[2, 674]=2.42, P=.0900$ ), and between target types and repeat block ( $F[4, 674]Y=Y8.82, P<.0001$ ). There was no significant interaction among trait anxiety, repeat block, and target types ( $F[4,674]=0.56, P=.6917$ ), between repeat block and cue types ( $F[6,674]=0.36, P=.9035$ ), among trait anxiety, repeat block, and cue types ( $F[6,674]Y=Y0.87, P=.5133$ ), among repeat block, target types, and cue types ( $F[12,674]=0.80, P=.6484$ ), and among trait anxiety, repeat block, target types, and cue types ( $F[12,674]=1.09, P=.3635$ ).

### 3.5. Alerting, orienting, and execution inhibition

The mean alerting was  $33.92 \pm 37.93$  ms for the low trait anxiety group and  $41.57 \pm 40.13$  ms for the high trait anxiety group, respectively. The mean orienting was  $40.07 \pm 40.97$  ms for the low trait anxiety group and  $39.05 \pm 35.26$  ms for the high trait anxiety group, respectively. The mean execution inhibition was  $96.61 \pm 111.90$  ms for the low trait anxiety group and  $110.70 \pm 58.99$  ms for the high trait anxiety group, respectively.

Multivariate analysis of the 3 subnetworks in the attention network including alerting, orienting, and execution inhibition showed no marked effect of trait anxiety ( $F[1, 57]Y=Y1.13, P=.2927$ ) and repeat block ( $F[2, 114]=2.24, P=.1114$ ) on the

alerting subnetwork. There was no significant interaction between trait anxiety and repeat block ( $F[2, 114]Y=Y1.48, P=.2318$ ). There was also no marked effect of trait anxiety ( $F[1, 57]Y=Y0.02, P=.8853$ ) and repeat block ( $F[2, 114]Y=Y1.42, P=.2457$ ) on the orienting subnetwork. No significant interaction was found between trait anxiety and repeat block ( $F[2, 114]Y=Y0.11, P=.8920$ ). In addition, there was no marked effect of trait anxiety ( $F[1, 57]=1.06, P=.3067$ ) and repeat block ( $F[2, 114]=1.47, P=.2378$ ) on the execution inhibition subnetwork. No significant interaction was observed between trait anxiety and repeat block ( $F[2, 114]Y=Y1.19, P=.3118$ ).

## 4. Discussion

The present study surveyed a cohort of military service personnel for trait and state anxiety. The study showed that the reaction time of the high trait anxiety group was significantly longer than that of the low trait anxiety group for the 4 cue types and for incongruent, congruent, and neutral target. Furthermore, the accurate rate of the high trait anxiety group for incongruent, congruent, and neutral target was significantly higher than that of the low trait anxiety group. These findings suggested that military service personnel with high trait anxiety exhibit altered reaction to cues and targets in terms of prolonged reaction time but

**Table 4****Multivariate analysis of determinants of reaction accuracy rate.**

Effect	Freedom of numerator	Freedom of denominator	F	P
Group	1	674	5.90	.0154
Time	2	674	8.27	.0003
Group*time	2	674	2.42	.0900
Target	2	674	36.72	<.0001
Group*target	2	674	0.23	.7968
Time*target	4	674	8.82	<.0001
Group*time*target	4	674	0.56	.6917
Cues	3	674	0.39	.7602
Group*cues	3	674	0.07	.9759
Time*cues	6	674	0.36	.9035
Group*time*cues	6	674	1.42	.2035
Target*cues	6	674	0.18	.9829
Group*target*cues	6	674	0.12	.9941
Time*target*cues	12	674	0.80	.6484
Group*time*target*cues	12	674	1.09	.3635

enhanced accuracy. Trait anxiety is a stable personal trait, and persons with high trait anxiety typically experience anxiety in threatening situations. This new finding that relative to low trait anxiety individuals, high trait anxiety individuals had more prolonged reaction time but enhanced accuracy rate suggests compromised efficiency of cognitive processing of external stimuli, but not executive functioning in terms of reaction accuracy.

The reaction time in the attention network reflects the speed of the human brain in cognitive processing of external information. In the present study, military service personnel with high and low trait anxiety showed differences in reaction time and reaction accurate rate. The cognitive performances of high anxiety individuals are related to the threatening circumstances and these individuals are more prone to interpret external stimuli as dangerous signals when processing external stimuli.<sup>[12]</sup> It has been found that in long intermission, a more negative wave was observed in the frontal lobe of individuals with high anxiety, suggesting that individuals with high anxiety<sup>[13]</sup> expend more cognitive resources and cognitive efforts in tackling a target goal, which is consistent with our findings. We found that trait anxiety, which reflects individual differences in sensitivity to negative or threatening stimuli, exerted significant effect on reaction time and accurate rate in the attention network, suggesting that greater sensitivity to anxiety impairs cognitive performances but not executive functioning.

We observed no significant differences in alerting, orienting and execution inhibition between military service personnel with high trait anxiety and those with low trait anxiety. Pacheco-Unguetti et al<sup>[14]</sup> studied patients with anxiety disorder using the attention network test and found that anxiety disorder had significant interference effect compared to the control subjects and had difficulty in dissociating attention from neutral stimuli. Pathological anxiety is a combination of trait anxiety and state anxiety; trait anxiety is associated with a central to peripheral control mechanism, whereas state anxiety is associated with a peripheral to central control mechanism and is triggered by external stimuli. Pacheco-Unguetti et al<sup>[14]</sup> found that trait anxiety was related to deficiencies in the executive control network, whereas state anxiety was associated with an overfunctioning of the alerting and orienting networks. Gao et al<sup>[15]</sup> showed that patients with generalized anxiety disorder had impaired executive control function, whereas alerting and orienting network functioning was comparable to that of the controls. By contrast, we found no marked effect of trait anxiety on the alerting, orienting, and the execution inhibition subnetwork. This difference from the studies by Pacheco-Unguetti et al<sup>[14]</sup> and Gao et al is partially because of the nature of the cohort in this study, who were young and healthy individuals. Furthermore, neutral stimuli were used in the present study, which did not activate the emotion circuit to generate state anxiety in individuals with high trait anxiety. Individuals with high trait anxiety may only show changes in the functioning of the attention network in response to emotional stimuli and under evaluation scenarios. Therefore, trait anxiety was less likely to influence the attention network in the present study. In addition, military servicemen and servicewomen receive military training and psychological wellbeing education. Any difference, if present, in functioning of the attention network will be obscured by military training between individuals with high and low trait anxiety. It has been shown that specific military training may increase the reaction time and accurate

rate and psychological wellbeing education may improve the psychological wellbeing of military personnel and reduce unhealthy emotions, which increase stress-coping capacity of military servicemen and servicewomen under stressful circumstances.<sup>[16,17]</sup> Therefore, military training and psychological wellbeing education may compensate deficits in cognitive performances of individuals with high trait anxiety.

The above findings have some practical and theoretical implications for future work. However, there were still some limitations of present study to consider. First, there was a deficiency in subject structure. That is majority of the participants were male. Second, cues in present study were limited to common ones. Therefore, the emotional cues should be included in future researches, so that it could be assessed how emotional information mediates the attention network in high and low trait anxiety individuals.

In conclusion, the current findings show that time for cognitive processing of external information, but not executive functioning, was compromised in high trait anxiety personnel. Our findings indicate that interventional strategies to improve the psychological wellbeing of military servicemen and servicewomen should be implemented to improve combat mission performance.

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