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Impact of Cognitive Readiness Training on Brain Wave Patterns in the Military Personnel

Ahmad-Ali Naji[1] (MSc), Isaac Rahimian-Boogar[1] (PhD), Siavash Talepasand[2] (PhD)

1. Department of Clinical Psychology, Faculty of Psychology and Educational Sciences, Semnan University, Semnan, Iran
2. Department of Educational Psychology, Faculty of Psychology and Educational Sciences, Semnan University, Semnan, Iran

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Corresponding Author:
Isaac Rahimian-Boogar,
Department of Clinical Psychology,
Faculty of Psychology and Educational Sciences,
Semnan University,
Semnan,
Iran
E-mail: i_rahimian@semnan.ac.ir

Abstract

Introduction: Military operations have become more complex and require cognitive readiness to adapt to the conditions that match the individual's brain reactions. The present study aims to investigate the impact of cognitive readiness training on brain wave patterns.

Method: This research was quasi-experimental with a control group and pretest-posttest design. The population included 38military officers. Furthermore, Operational Strategic Management Simulation (OSMS) and the Quantitative Electroencephalogram (QEEG) were used. Moreover, a 40-session cognitive readiness course was provided for the experimental group, and an 11-session course was presented for the control group. Data were analyzed using the MANCOVA test.

Results: According to the findings of the present study, cognitive readiness training reduces beta and delta waves in the frontal and central regions. This training increases in the alpha and theta waves in all the areas of the brain (Eta Squared = 0.35 - 0.52) ($p<0.01$). Also, sLORETA showed that the maximum change was observed in the alpha wave in the dorsolateral prefrontal cortex.

Conclusion: By promoting cognitive readiness, individuals can make better decisions, optimize performance, and minimize cognitive and emotional burdens. Implementing tools like QEEG assessments can provide insights into individual differences and abilities, aiding in task suitability evaluation. Embracing cognitive readiness can ultimately help reduce human errors, enhance independence, and improve performance in high-stress military environments.

Keywords: Cognitive Readiness Training, Brain Waves, Military

Introduction

Cognitive science theorists aim to recreate military groups, such as the brain, to be flexible and capable of optimal reactions in changing environmental situations and unpredictable challenges [1]. Moreover, military operations have become more complex, requiring soldiers to use their skills and knowledge in new situations [2]. To address these challenges, cognitive readiness is a mental process that helps individuals prepare for such situations [3]. Cognitive readiness, the ability to effectively process information, make decisions, and adapt to change, is a critical attribute for military personnel operating in complex and unpredictable environments [4]. Cognitive Readiness Training (CRT) has emerged as a promising approach to enhance these cognitive abilities. Recent research has delved into the impact of CRT on brain wave patterns, shedding light on the underlying mechanisms of its effectiveness [5, 6].

Furthermore, changes in the brain's structures play a crucial role in maintaining the long-term effect of psychological training and achieving optimal performance [7]. Thus, it is necessary to select military decision-makers who can react favorably to situational developments and rethink organizational and decision-making processes to adapt to complex, insecure, variable, and unpredictable conditions [8].

One of the new principles in intended cognition is the focus on establishing cognitive readiness, which is being discussed and implemented among the latest approaches in organizations [4]. This focus has led to the development of new models with cognitive dimensions that explain the role of cognitive approaches and experiences of military forces based on cognitive sciences [9]. From a cognitive perspective, the method of information processing, conclusion, thinking, and decision-making is evaluated [10]. Thus, the performance of the military in the operational environment follows the same principles [4]. The battlefield can be seen as a cognitive field where the experiences, cognitions, and general cognitive readiness of commanders play a crucial role in explaining and interpreting information, decision-making methods, directing resources, and creative acceptance [11]. Paying attention to cognitive readiness leads to the development of essential performance competencies and provides the basis for desirable performance [12].

To understand the relationship between the brain and the mind process, neuroimaging is used by researchers. Individual differences have been observed in styles, capabilities, and cognitive strategies [7]. These differences in cognitive task performance are often associated with significant variations in the activities of brain regions known as the BOLD, which can indicate an individual's performance in ambiguous situations [13]. Additionally, studies have shown differences in brain wave neural activities and intensity between individuals with low cognitive readiness and those with higher cognitive readiness [8, 14]. For example, Laarni et al. [11] demonstrated that brain wave patterns change after cognitive training exercises in a battle tank simulator task.

The emotions experienced on the battlefield are generally caused by the stimulation of specific brain parts responsible for the initial emotional interpretation of Electroencephalography (EEG) signals from the autonomic nervous system [15]. However, brain areas responsible for information processing may also be involved in other functions, such as memory, attention, association, perception, and processing of internal states or external stimuli [16]. During specific and dynamic processes, other brain areas involved in processing cognitive and emotional information are activated [6]. This suggests that the brain does not have an exclusive center to interpret ambiguous situational conditions. Strengthening non-specialized centers can also affect the function of every part of the brain and EEG signals [17]. Furthermore, through training, it is possible to change how different brain parts function, which can be observed in the occurrence and intensity of brain wave patterns. These observations raise questions about the long-lasting effects of cognitive readiness on individual performance, whether these effects cause changes in brain wave patterns, and which specific parts of the brain are more susceptible to such changes?

Method

The present research was quasi-experimental with a control-group pretest-posttest design. Quasi-experimental designs are often used when it is not possible or ethical to randomly assign participants to different groups. In this case, the research objectives may involve studying the impact of a specific intervention or treatment, and it may not be feasible to use a randomized controlled trial. The statistical population of this section included 45 senior officers of a military centers who volunteered to participate in the research. Regarding the inclusion and exclusion criteria, 38 members were selected and assigned to two experimental and control groups. To ensure that participants truly volunteered and were not coerced into participation, a thorough recruitment process was implemented. This process involved providing clear and transparent information about the study's purpose, procedures, and potential risks and benefits. Participants were given sufficient time to consider their participation and were encouraged to ask any questions they had. Informed consent was obtained from all participants, and they had the right to withdraw from the study at any time without any negative consequences.

The sample size was estimated using the G-power software. Considering the meta-analysis research of Crameri et al. [18], the effect size was 0.48.

Participants provided voluntary informed consent to participate in the research. The exclusion criteria included mental disorders assessed using the psychiatric diagnostic interview based on DSM-5-TR. Other exclusion criteria encompassed conditions such as head tumors, brain tumors, hyperhidrosis, cardiovascular and respiratory diseases, and individuals with coronary stents. Before the study, all participants underwent pre-test measurements. Only the experimental group received training in cognitive readiness throughout the course. Subsequently, post-test evaluations were conducted for all subjects.

The tools Used in this study were as follows:

Military Situation Simulator: Operational Strategic Management Simulation (OSMS) was used to create stress in the military operation situation, which is a quasi-experimental technology made of several adapted scenarios (in task and consequence requirements). This simulation lasts for 35 minutes and plans two perfect individual and two group operations. Ultimately, a score from 1 to 20 is regarded for each scenario based on the individual's performance. As four scenarios were used in this research, the maximum score of 80 and the minimum score of 4 would mean the best and the worst performance, respectively. Kovbasiuk et al. [19], reported concurrent validity between 0.8 and 0.94 and Cronbach's alpha reliability of 0.69. Furthermore, this simulator has been optimized according to the Iranian military structure.

Brain Wave Patterns: The Quantitative Electroencephalogram (QEEG) was used to record brain wave patterns. The Parto-E Danesh Company has presented this device. In addition, a Neuroscan amplifier and a cap were also used. This device recorded the participants' EEG for 19 channels using monopolar montage applying the international 20-10 system. The wave spectrum is recorded for four delta, theta, alpha, and beta waves [20]. The absolute power of four frequency bands was measured and expressed in Microvolts in different brain areas, i.e., the frontal, central, temporal, parietal, and visual areas in the left and right hemispheres. The quantification process uses Neuroguide software and Fast Fourier Transform (FFT) [16].

Cognitive Readiness Training: The cognitive readiness course spanned a duration of three months, consisting of 40 sessions, each lasting for 90 minutes. The course focused on enhancing knowledge (11 sessions), skills (20 sessions), and attributes (9 sessions) in accordance with the cognitive readiness model designed for Iranian military personnel [21].

The measurement procedure was such that the participants were exposed to four scenarios in the operational and strategic management simulator, and QEEG were recorded while dealing with the issues of the scenarios. After the pre-test stage, the cognitive readiness protocol was implemented, during which 40 training sessions (group training for 90 minutes) were held for the experimental group. Finally, to perform the post-test stage, four different scenarios with pre-test were performed for all participants of two groups, and QEEG was recorded while responding to the scenarios.

In order to describe the data, frequency, mean and standard deviation and to test the hypotheses, MANCOVA was used with SPSS-25 software. The rationale behind selecting MANCOVA in this study is twofold. Firstly, MANCOVA allows the examination of the effects of independent variables on multiple dependent variables simultaneously. So, by using MANCOVA, researchers can account for the interrelationships among these variables and analyze their collective impact. Secondly, to control the effect of the pre-test on the post-test, by using MANCOVA, researchers can statistically control these potential confounding variables, thereby increasing the precision of the analysis.

However, in general, the interpretation of brain maps involves examining the spatial distribution and activation patterns of brain regions based on the recorded EEG data. Matlab and sLORETA are software tools commonly used for the analysis and visualization of EEG data.

Results

The average age of the participants in the experimental and control groups was 35.73 and 35.68 years, respectively, and its standard deviation was 2.91 and 3.43, which did not have a significant difference ($t=0.03$; $p=0.97$). The absolute power of four brain waves is presented in Table 1.

Table 1 reveals that the absolute power of theta and alpha generally increases, and the absolute power of beta and delta decreases. In addition, the data distribution in the stages and groups was normal ($p>0.05$). However, by examining the assumption of the analysis, it was found that the parametric test of MANCOVA can be used. Table 2 shows the multivariate tests in which Wilks's lambda test results are reported.

Table 3 shows that the interaction of the areas related to the waves with the independent variable (group) is not significant in the pre-test stage ($p> 0.01$), which reveals the homogeneity of the regression slopes and confirms another hypothesis of the MANCOVA test. In addition, it can be perceived that the pre-test as a covariate variable has no significant effect on the proposed analytical model, and there is no significant difference between the two groups in this research stage ($p>0.01$). Moreover, no difference was observed between the two groups in the post-test stage in terms of areas of the delta ($F=2.99$), theta ($F=5.05$), alpha ($F=2.11$) and beta waves ($F=2.61$) ($p<0.01$). Therefore, there are differences between the areas related to the waves in the two groups, and the effects between objects should be investigated.

It was shown in Table 3 that the analytical model of the research is significant for all components ($p< 0.01$), but delta waves are significant in two frontal and central lobes ($p< 0.01$). Furthermore, delta waves are significant in the frontal, central, and parietal lobes. ($p<0.01$)

Loretta technique output indicates that the main producer of alpha wave is located in Brodmann area 9, that is, in the frontal lobe in the left hemisphere. So, the CRT led to the most significant change in the alpha wave and dorsolateral prefrontal cortex (Figure 1).

Table 1. Absolute Power (μV^2) of Brain Waves Separately the Stages and Groups

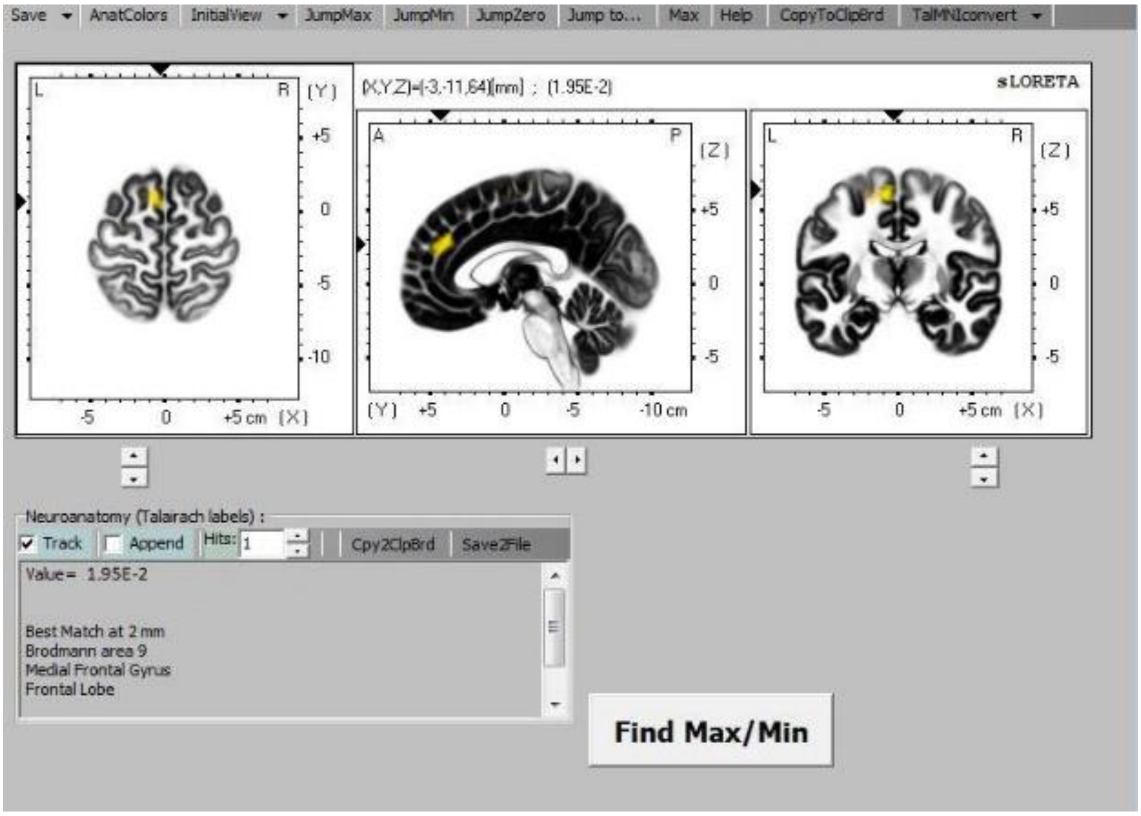
Wave	Lob	level	group	M	SD	Wave	Lob	level	group	M	SD
Delta	frontal		experiment	18.82	5.18	Alpha	frontal		experiment	9.49	2.82
			control	20.79	5.30				control	9.62	3.29
		Post-test	experiment	13.31	2.94			Post-test	experiment	15.95	2.83
			control	19.55	4.89				control	9.55	3.74
	Central		experiment	6.11	1.81		Central		experiment	10.26	3.74
			control	7.22	2.23				control	9.78	3.11
		Post-test	experiment	4.95	2.38			Post-test	experiment	11.37	4.65
			control	7.35	2.31				control	8.38	4.37
	parietal		experiment	10.16	2.83		parietal		experiment	12.98	6.74
			control	9.94	2.11				control	15.17	6.93
		Post-test	experiment	8.84	4.05			Post-test	experiment	20.56	6.37
			control	8.88	3.47				control	14.90	6.57
	temporal		experiment	10.59	2.14		temporal		experiment	11.55	4.66
			control	10.95	2.84				control	11.47	4.92
		Post-test	experiment	9.58	2.91			Post-test	experiment	16.12	4.41
			control	9.52	2.83				control	11.23	4.33
	occipital		experiment	11.76	3.55		occipital		experiment	14.22	4.36
			control	10.82	2.39				control	14.51	3.86
		Post-test	experiment	10.22	4.87			Post-test	experiment	15.28	3.45
			control	11.22	4.61				control	14.83	3.84
Theta	frontal		experiment	12.67	3.72	Beta	frontal		experiment	12.98	5.71
			control	13.6	3.38				control	13.39	5.79
		Post-test	experiment	16.14	2.96			Post-test	experiment	9.18	5.98
			control	13.31	3.88				control	13.08	5.03
	Central		experiment	7.25	2.23		Central		experiment	10.99	2.09
			control	7.55	2.37				control	11.43	2.84
		Post-test	experiment	12.96	2.04			Post-test	experiment	8.65	2.63
			control	7.22	2.26				control	11.43	2.71
	parietal		experiment	8.64	2.83		parietal		experiment	13.11	3.42
			control	7.94	3.26				control	13.25	3.22
		Post-test	experiment	10.01	4.28			Post-test	experiment	9.46	2.73
			control	7.37	3.39				control	13.51	3.11
	temporal		experiment	11.10	3.15		temporal		experiment	18.09	5.58
			control	10.92	3.05				control	20.39	5.48
		Post-test	experiment	10.89	2.37			Post-test	experiment	13.93	7.96
			control	11.12	3.15				control	19.71	7.36
	occipital		experiment	11.62	2.54		occipital		experiment	15.67	8.37
			control	11.46	3.04				control	16.74	8.06
		Post-test	experiment	10.79	3.49			Post-test	experiment	10.73	6.55
			control	11.68	3.69				control	15.96	5.77

Table 2. Wilks' Lambda Multivariate Test for Delta Wave Direction

wave	Source	Value	F	df	P	Eta	wave	Source	value	F	df	P	Eta
Delta	Group	0.65	2.99	5	0.032	0.39	Alpha	Group	0.45	1.11	10	0.043	0.32
	Group×frontal	0.87	0.60	5	0.698	0.12		Group×frontal	0.80	1.05	5	0.412	0.91
	Group×central	0.44	0.38	5	0.322	0.15		Group×central	0.85	0.77	5	0.578	0.15
	Group×parietal	0.80	1.05	5	0.143	0.19		Group×parietal	0.84	0.82	5	0.543	0.15
	Group×temporal	0.69	1.96	5	0.124	0.30		Group×temporal	0.72	1.64	5	0.190	0.27
	Group×occipital	0.65	2.34	5	0.075	0.34		Group×occipital	0.76	1.32	5	0.291	0.23
	Frontal pre-test	0.80	1.09	5	0.392	0.19		Frontal pre-test	0.84	0.83	5	0.538	0.16
	Central pre-test	0.90	0.48	5	0.787	0.09		Central pre-test	0.73	1.62	5	0.201	0.26
	Parietal pre-test	0.72	1.63	5	0.193	0.27		Parietal pre-test	0.78	1.19	5	0.343	0.21
	Temporal pre-test	0.71	1.84	5	0.141	0.29		Temporal pre-test	0.73	1.62	5	0.195	0.27
	Occipital pre-test	0.61	2.74	5	0.05	0.38		Occipital pre-test	0.90	0.44	5	0.814	0.09
Theta	Group	0.21	5.05	10	0.001	0.52	Beta	Group	0.39	2.61	10	0.014	0.37
	Group×frontal	0.76	1.33	5	0.278	0.23		Group×frontal	0.71	1.75	5	0.165	0.28
	Group×central	0.80	1.09	5	0.392	0.19		Group×central	0.65	2.28	5	0.082	0.34
	Group×parietal	0.93	0.33	5	0.888	0.07		Group×parietal	0.91	0.39	5	0.849	0.08
	Group×temporal	0.66	2.22	5	0.088	0.33		Group×temporal	0.90	0.46	5	0.795	0.09
	Group×occipital	0.76	1.39	5	0.266	0.24		Group×occipital	0.91	0.38	5	0.852	0.08
	Frontal pre-test	0.12	0.46	5	0.666	0.12		Frontal pre-test	0.70	1.86	5	0.142	0.29
	Central pre-test	0.86	0.70	5	0.628	0.13		Central pre-test	0.87	0.65	5	0.663	0.12
	Parietal pre-test	0.82	0.91	5	0.489	0.17		Parietal pre-test	093	0.32	5	0.895	0.06
	Temporal pre-test	0.69	1.93	5	0.130	0.30		Temporal pre-test	0.91	0.40	5	0.838	0.08
	Occipital pre-test	0.08	0.42	5	0.825	0.08		Occipital pre-test	0.85	0.74	5	0.597	0.14

Table 3. Testing the Effects between Objects in Terms of Brain Waves

Wave	Source	Lobe	df	F	P	wave	Source	Lobe	df	F	P
Delta	Model	Frontal	7	281.68	0.001	Alpha	Model	Frontal	7	82.13	0.001
		Central	7	44.27	0.001			Central	7	30.02	0.001
		Parietal	7	32.30	0.001			Parietal	7	38.08	0.001
		Temporal	7	56.16	0.001			Temporal	7	33.35	0.001
		Occipital	7	32.66	0.001			Occipital	7	73.08	0.001
	Group	frontal	2	16.46	0.001		Group	Frontal	2	24.72	0.001
		Central	2	4.02	0.028			Central	2	6.27	0.005
		Parietal	2	2.25	0.122			Parietal	2	8.58	0.001
		Temporal	2	2.46	0.101			Temporal	2	4.07	0.027
		Occipital	2	0.74	0.484			Occipital	2	5.40	0.010
		Frontal	1	0.45	0.507			Frontal	2	0.20	0.656
		Central	1	2.62	0.115			Central	1	2.16	0.151
		Parietal	1	1.14	0.807			Parietal	1	0.04	0.836
		Temporal	1	1.30	0.261			Temporal	1	4.83	0.036
		Occipital	1	1.60	0.215			Occipital	1	1.17	0.286
Theta	Model	Frontal	7	8.71	0.001	Beta	Model	Frontal	7	22.95	0.001
		Central	7	130.50	0.001			Central	7	82.92	0.001
		Parietal	7	35.22	0.001			Parietal	7	86.35	0.001
		Temporal	7	59.56	0.001			Temporal	7	30.28	0.001
		Occipital	7	47.26	0.001			Occipital	7	24059	0.001
	Group	Frontal	2	8.82	0.001		Group	Frontal	2	2.85	0.073
		Central	2	39.50	0.001			Central	2	11.14	0.001
		Parietal	2	3.89	0.031			Parietal	2	11.03	0.001
		Temporal	2	1.78	0.185			Temporal	2	5.22	0.011
		Occipital	2	1.88	0.169			Occipital	2	2.61	0.090
		Frontal	1	0.51	0.479			Frontal	1	1.24	0.273
		Central	1	0.39	0.535			Central	1	1.31	0.261
		Parietal	1	0.05	0.824			Parietal	1	0.84	0.366
		Temporal	1	2.65	0.113			Temporal	1	0.16	0.687
		Occipital	1	0.01	0.914			Occipital	1	2.23	0.133



(X,Y,Z)=(-3,-11,64)(mm) ; (1.95E-2)

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Value= 1.95E-2


Best Match at 2 mm
Brodmann area 9
Medial Frontal Gyrus
Frontal Lobe
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Figure 1. Alpha wave production site.

Discussion

In this study, CRT was found to decrease beta waves in most brain regions and reduce delta waves in the frontal and central lobes. Additionally, this training increased alpha waves, except in the occipital region, and theta waves in the frontal, parietal, and central lobes. The most significant change was observed in the alpha wave and Brodmann area 9, which corresponds to the Dorsolateral

Prefrontal Cortex (DLPFC). The observed changes in brain wave patterns have significant functional significance, particularly in relation to cognitive processes. Understanding these changes can shed light on their impact on decision-making and problem-solving, particularly in military contexts.

The significance of beta wave reduction or normalization lies in optimizing cognitive functions. Excessive beta wave activity might indicate heightened alertness and focus, but it can also lead to inefficient energy consumption [22]. In military contexts, where sustained cognitive performance is required, managing energy resources becomes crucial [23]. By reducing excessive beta wave activity, individuals can conserve energy and allocate it to critical cognitive processes such as problem-solving, judgment, and decision-making [17]. This can improve decision-making speed, accuracy, and effectiveness, particularly in fast-paced and high-stakes situations. Cognitive readiness, which reduces the emotional burden and moderates the cognitive burden, tries to lead the person towards logical reactions away from intense physical experiences (such as heart palpitations) through its strategies and topics [24]. Cognitive readiness helps the individual to cope with problems in a cognitive-oriented way [4]. For instance, the general exercises include the exercise of proper questioning (identifying the problem), problem-solving (process-oriented and technique-oriented), self-awareness skills in problem-solving, time management in problem-solving, and skill of connection between the components, which is attempted to react to an event irrespective of the experienced emotion [14].

Delta waves, on the other hand, are associated with suspended external consciousness and can be intensified during stressful situations [22]. In military scenarios, where individuals face high levels of stress and are exposed to potentially traumatic events, managing stress becomes essential for optimal decision-making [25]. By reducing reliance on fight-or-flight responses and avoiding excessive fantasizing, individuals can maintain a more rational and logical approach to problem-solving [17]. This can lead to better judgment and decision-making under pressure. In this case, the critical point is suitable consciousness and avoiding fantasy in decision-making, problem-solving, and stressful situation [19]. If the individual can reach the optimum level of delta waves in CRT, clear their mind of all surrounding worries and stimuli, and then return quickly to the actual situation, they can easily use their cognitive skills to control the situation [26]. Cognitive readiness emphasizes consciousness, situational awareness, and applying all skills, knowledge, and characteristics so that a person can reach this situation [26]. In the existing cognitive readiness protocol, especially situational awareness and metacognition, special attention has been paid to the mindfulness, planning, and monitoring of performance, thoughts, and emotions that can improve consciousness, decision-making, and problem-solving [21].

Theta waves, on the other hand, known for their role in learning and understanding information, can have practical implications for military training and skill acquisition. Increased theta wave activity signifies a readiness to accept and process new information [22]. In military training, where learning new skills and adapting to novel situations is critical, having a brain primed for learning can greatly enhance cognitive performance. It allows efficient retention of information and promotes deep understanding, both of which are crucial in military contexts [6].

When individuals experience high levels of theta waves while awake, they gain a deep understanding of the mind’s ability and power. This understanding allows them to feel calm and at ease when facing life experiences [22]. Low levels of theta waves are associated with symptoms of anxiety, weak emotional awareness, and higher stress levels [17]. In contrast, an optimal level of theta wave activity leads to maximum creativity, a profound emotional connection with oneself and others, enhanced intuition, and overall relaxation. The brain, in this state, becomes open and receptive to new information and knowledge [18]. The increase in theta waves in the central and frontal regions of the brain may be due to the inhibitory effects on other brain regions, such as the posterior and lateral regions. This inhibition allows a focused and heightened mental performance [22]. Additionally, the presence of theta waves without a shift to beta and alpha waves suggests that the individual is experiencing a state of high cognitive readiness [6].

It is believed that the structures responsible for producing alpha waves play a role in both stimulating and inhibiting conditions, contributing to the observed changes in theta waves [22]. Furthermore, the increase in theta wave activity may be attributed to the involvement of memory-related structures, including the hippocampus, para-hippocampus, and limbic structures [17]. During CRT, individuals process new information by incorporating their prior learnings and stored memories [1]. This process further activates the hippocampus and its associated structures, resulting in an increase in theta wave activity [27]. Overall, theta waves play a crucial role in cognitive readiness and information processing [12]. They facilitate a shift from an emotional and short-term state to a cognitive and long-term state, enabling individuals to effectively process new experiences and accumulate knowledge.

Finally, the most notable changes were observed in alpha waves throughout various brain regions. Alpha waves are associated with a state of relaxation and a lack of concentrated mental activity. They have been found to prevent depression, anxiety, and stress, while also enhancing creativity [22]. Alpha waves are not only linked to specific brain structures, such as the thalamus with its emotional and impulsive reactions, but also to the cortical structures responsible for logical and planned responses [27]. Experimental findings support the notion that increased alpha wave activity and active suppression of unconscious stimuli provide evidence for their facilitating and inhibitory roles in cognitive processes. In other words, alpha waves perform both inhibitory and facilitating functions. When a particular part of the brain requires attention and concentration, alpha wave activity in that region increases, leading to improved performance [28]. This wave ensures that the brain remains in an active and ideal state, free from anxiety and cognitive burden. Conversely, a decrease in alpha wave activity may result in reduced efficiency in that specific brain region [22].

In military contexts, maintaining a relaxed state and staying calm are crucial for effective decision-making, especially in high-pressure situations. The increase in alpha waves contributes to this desired mental state [24]. By fostering relaxation, creativity, and the prevention of depression, anxiety, and stress, alpha waves enable military personnel to approach challenges with clarity and a creative mindset. The enhanced alpha wave activity can lead to more innovative solutions and greater adaptability in rapidly changing environments [20]. The ability to remain calm and focused under pressure allows military personnel to make sound decisions and think outside the box when faced with complex problems. Overall, the connection between cognitive readiness, alpha wave activity, and mindfulness practices highlights their vital role in optimizing performance in military settings [14].

In the context of cognitive readiness and its impact on the brain, significant changes were observed in the alpha wave activity and the DLPFC. The DLPFC is a key area of the brain with connections to various regions, including the orbitofrontal cortex, thalamus, basal ganglia, hippocampus, and neocortex [29]. It plays a crucial role in executive functions such as working memory, cognitive flexibility, planning, inhibition, and abstract reasoning. However, all complex mental activity requires the additional cortical and subcortical circuits with which the DLPFC is connected [30]. The DLPFC is also the highest cortical area in motor planning, organization, and regulation [31]. These findings show that cognitive readiness has been able to cause changes in an essential area of the brain, which, on one hand, is associated with the general structure of the brain [32]. Also, it improves the function of the frontal part of the brain (executive functions) as well as skills such as decision making and problem-solving through its various tasks and functions [31].

The examination of brain waves using LOTERA software reveals that cognitive readiness induces changes in the DLPFC, enhancing its functions and improving the overall performance of the frontal part of the brain. These changes have significant implications for military personnel, as the DLPFC's executive functions are essential for decision-making and problem-solving abilities [30]. By promoting cognitive readiness, military personnel can experience enhanced alpha wave activity and increased functioning of the DLPFC. This, in turn, improves their capabilities in various cognitive tasks and executive functions, allowing them to make informed decisions, adapt to challenging situations, and approach problem-solving with efficiency and creativity. The connectivity of the DLPFC with other brain regions further supports its role in facilitating cognitive readiness and optimizing performance in military contexts [31].

Limitations of the present research should be acknowledged in order to provide a comprehensive understanding of its scope and implications. Several limitations were encountered during the study, including the absence of certain stressors in the simulator scenarios and the sensitivity of the equipment used in the laboratory. One limitation of the study was that the scenarios implemented in the simulator did not incorporate stressful factors such as sleep deficiency, injury, fatigue, pain, hunger, and thirst. These stressors, which are commonly encountered in real-life situations, were excluded from the research due to practical and ethical constraints. Future studies could consider incorporating these stressors to provide a more comprehensive understanding of cognitive readiness in stressful situations.

Furthermore, the equipment utilized in the laboratory, including the brain wave recorders, exhibited sensitivity to movement, metal objects (such as weapons and general personal facilities), and electronic devices (such as wireless sets). This sensitivity of the equipment may have introduced inconsistencies between laboratory measurements and real-world environments. Consequently, the generalizability of the study's findings to real-life situations may be affected, and caution should be exercised when extrapolating the results to practical applications. While the current research provides valuable insights into cognitive readiness, these limitations indicate areas for further exploration and improvement. Future studies could address these limitations by incorporating a wider range of stressors and using more robust and resilient equipment that better replicates real-world conditions. Such efforts would contribute to a more nuanced understanding of cognitive readiness and enhance the applicability of the findings in real-life contexts.

Addressing these limitations in future research by incorporating a wider range of stressors and using more resilient equipment would enhance understanding and applicability of cognitive readiness in practical contexts. In this respect, regarding the necessity of reducing human errors and the militaries' intellectual and practical independence in unpredictable and ambiguous situations, the individuals are suggested to take into account cognitive readiness in order to be able to use knowledge, skills, and attitude to make decisions and show an optimal performance with the least cost as well as the least cognitive and emotional burden. Furthermore, the implementation of the short-term (one month), mid-term (six months), and long-term (one year) follow-up phases can provide more information about the effectiveness of cognitive readiness.

Conclusion

In conclusion, CRT holds great potential for military personnel. The present study highlights the importance of being prepared to use knowledge, skills, and an attitude in unpredictable and ambiguous situations. By promoting cognitive readiness, individuals can make better decisions, optimize performance, and minimize cognitive and emotional burdens. Implementing tools like QEEG assessments can provide insights into individual differences and abilities, aiding in task suitability evaluation. Furthermore, conducting follow-up phases can offer valuable information about the long-term effectiveness of CRT. Embracing cognitive readiness can ultimately help reduce human errors, enhance independence, and improve performance in high-stress military environments. These changes can lead to improved performance, adaptability, and resilience in military personnel, ultimately contributing to mission success in challenging environments. Considering individual differences, cognitive readiness attempts to pave the way for the individual to cope with the environmental features rationally away from excitement with the aim of optimal performance in an unpredictable and ambiguous environment.

Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Approval

The manuscript includes a statement describing the ethical approval process for obtaining informed consent (IR. SEMUMS. 1401.204). This process involved obtaining approval from the relevant institutional review board or ethics committee. The informed consent process ensured that participants were fully informed about the study's purpose, procedures, potential risks and benefits, confidentiality measures, and their rights as participants. The manuscript also clearly defines the exclusion criteria used to screen potential participants and ensure the study's integrity and participant safety.

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