UDC 159.953.3 **doi**: 10.21702/rpj.2020.1.3 ***Original research article***

Effects of the Moderated Stress Exposure on the Short-Term Memory Capacity in Cadets

Ekaterina V. Bityutskaya[1], Natalya A. Lebedeva[2*], Julia R. Tsalikova[1]
[1] Lomonosov Moscow State University, Moscow, Russian Federation
[2] Moscow City University of Management of the Government of Moscow, Moscow, Russian Federation
[*] Corresponding author. E-mail: nattalea@mail.ru
ORCID ID: https://orcid.org/0000-0001-6117-1063, https://orcid.org/0000-0001-8727-8774, https://orcid.org/0000-0002-0778-1749

Abstract

Introduction. The effects of moderate-intensity stressors on short-term memory are studied, which is relevant to the professional training of first responders (firefighters) when preparing them for emergencies. This study investigates changes in the capacity of short-term memory under stress. Significant differences were found among memory parameters of fire cadets and students of civilian specialties. To the best of our knowledge, this is the first experimental study of the stress impact on the short-term memory capacity that takes into account professional education and training of the respondents.

Methods. The study comprised 90 respondents, including 50 fire cadets of the Academy of State Fire Service and 40 students of Moscow universities. The subjects were divided into an experimental group and three control groups. Stressful stimuli (disturbing photo- and audio materials) were presented to respondents from two groups; respondents in two other groups were presented with neutral stimuli. The short-term memory capacity before and after the stressful stimulation was assessed with the Digit Span Test. The physiological signals of the subjects were measured during the experiment.

Results. In fire cadets, stress resulted in a significant increase in memory capacity, while memory capacity showed a slight decrease in students. Physiological response to stressful conditions was different between students and fire cadets. Compared to cadets, the baseline muscle tension measures were higher in students. Compared to students, cardiovascular system parameters (systolic wave amplitude, pulse transit time) changed faster in cadets. However, these parameters changed not as substantially as those in students.

Discussion. In fire cadets, memory capacity and its change due to stressful effects were associated with levels of non-verbal intelligence. It might also be mediated by emergency professionals' competencies. The system of selection, psychological training, and counseling of fire cadets in the Academy of State Fire Service is considered to be an important factor in the stability of cognitive functions under stress.

Keywords

short-term memory, memory capacity, stress, Digit Span Test, goal, cognitive appraisal, stressor intensity, self-regulation, arousal, physiological parameters

Highlights

- Stress causes an increase in the capacity of short-term memory in the majority of fire cadets. It should be noted that future professional activity of fire cadets is closely related to emergencies.
- An increase in short-term memory capacity under stress might contribute to the performance of first responders, rescuers, and firefighters.
- The results are discussed in connection with the professional competencies of first responders and emergency professionals (optimism, positive self-appraisal of their own abilities), as well as with the fire cadets training system, which enables them to maintain self-control and stability when performing professional tasks in challenging situations.

For citation
Bityutskaya, E. V., Lebedeva, N. A., & Tsalikova, Yu. R. (2020). Effects of the moderated stress exposure on the short-term memory capacity in cadets. *Rossiiskii psikhologicheskii zhurnal (Russian Psychological Journal)*, *17*(1), 27–43. doi: 10.21702/rpj.2020.1.3

Received: January 30, 2020
Revision received: March 5, 2020
Accepted: March 9, 2020

Introduction

The specificity of professional activities in extreme jobs is determined by the need to work under stress of extreme intensity related to situations of emergency response or disaster cleanup operations. First responders must maintain an adequate perception of reality, make efficient decisions, and act purposefully, which is related to the stability of cognitive functions. Research on cognitive functioning under stress is important, as it is relevant to the professional training of first responders (rescuers) when preparing them for emergencies.

Several investigations demonstrated that short-term (working) memory is associated with resource distribution, attention, and behavior control and determines the efficiency of activity when performing difficult tasks (Barrett, Tugade, & Engle, 2004). Thus, short-term memory might be an essential factor for rescuers' performance under extreme conditions.

Some studies have noted that stress could improve or worsen cognitive functioning. This study aims to investigate memory functioning in fire cadets whose future professional activities are related to emergencies. Therefore, the analysis of factors and mechanisms that may explain the efficiency of task performance under stress is of our primary interest. In this context, we will examine the cognitive appraisal of stress, stressor intensity, and self-regulation.

Cognitive appraisal of stress as an activator

Some studies report that if individuals appraise stress as a challenge, they tend to overcome stressful situations more actively (Lazarus, 1991). Such an appraisal is characterized by the perception of stress as an opportunity to improve one's skills and experiences, to become stronger, etc. A person must be confident that his/her resources are sufficient to achieve success (Tomaka, Blascovich, Kelsey, & Leitten, 1993). The appraisal of stress as a challenge, in turn, mobilizes the person to overcome it and is negatively associated with avoidance (Blascovich & Tomaka, 1996; Tomaka et al., 1993).

A recent meta-review shows that the appraisal of stress as a challenge is associated with a more efficient activity in strenuous conditions (Hase, O'Brien, Moore, & Freeman, 2019). Thus, surgeons with such appraisals better performed surgical procedures and demonstrated better motor skills and attention characteristics (Vine, Freeman, Moore, Chandra-Ramanan, & Wilson, 2013). When practicing engine breakdown scenario, the pilots appraising difficult situations as a challenge were able to use relevant information more effectively and to land more safely (Vine et al., 2015).

Some studies tested a hypothesis that the appraisal of stress and individual physiological states may be associated. It was shown, for example, that a positive attitude towards stress, where the situation is perceived as an opportunity to mobilize one's abilities, is associated with a moderate activation of cortisol production (Crum, Salovey, & Achor, 2013). Another study by Jamieson, Mendes, Blackstock, and Schmader involved students preparing for their examinations. Before examinations, they gave arguments for the positive impact of stress on exam performance on the experimental group students. The study results suggested that a positive attitude towards stress determined, firstly, better exam scores among more effectively; on the other hand, this group had higher sympathetic tone levels compared to the control group (Jamieson, Mendes, Blackstock, & Schmader, 2010).

Effects of stressor intensity on cognitive activity

Currently, an inverse U-shaped curve between arousal and cognitive processes, first introduced by Easterbrook in his report (1959), is a very intensely discussed topic. The U-shaped curve describes greater attention efficiency and more effective memory functioning in moderate stress. More recent works defined this concept more precisely; it was postulated that a moderate level of emotional tension could enhance memorizing and reproducing of information, particularly, of emotional information (McGaugh, 2006; Cahill, Gorski, & Le, 2003; Buchanan & Lovallo, 2001). Moreover, speed ratings in cognitive task performance are improved under stress of low or moderate intensity (Hancock & Weaver, 2005). As the level of the excitement increases, the memory of event details decreases due to attention narrowing at memorizing (Buchanan, Tranel, & Adolphs, 2006; Sharot & Phelps, 2004).

The U-shape curve investigations are related, specifically, to the factors that mediate it. For example, different patterns could be observed for positive or negative emotions of the same intensity. This data supports the idea that the level of arousal alone cannot fully explain cognitive functioning under stress (Mather, 2007; Sharot & Phelps, 2004; Levine & Pizarro, 2004; Levine & Burgess, 1997; Bargh & Cohen, 1978). Furthermore, a mediating role of emotional regulation was described. Persons who suppress their emotions (in their everyday life or following the instructions of the experiment), memorized the emotional content of events worse (Bonanno, Papa, Lalande, Westphal, & Coifman, 2004).

Self-regulation and cognitive activity

The issues of the efficiency of cognitive functioning are discussed in studies of self-regulation. To explain individual characteristics of self-regulation, they use the concept of functional states, which is related to performance efficiency and optimal goal achievement (Leonova & Kuznetsova, 2015). Functional states are especially important in emergencies, as they determine the results of professional activity (Dikaya, 1999). A 'productive tension' is defined as an optimal state by contrast with distress, which is considered to be an adverse state (Dikaya & Shchedrov, 1999).

We consider that the conclusion of the purposeful character of activity in successful coping with stress is very important for our study (Dikaya, 1999; Leonova & Kusnetzova, 2015; et al.). In his work Zotov (2011) demonstrated that voluntary regulation of activity could be maintained if a cognitive activity was purposeful. Among stress resistance factors, Bodrov & Oboznov (2000) distinguish the ability to create the estimated images of result achievements and anticipative schemes, which is associated with goal-setting. Based on empirical data, S. A. Shapkin shows that the achievement of goals related to high performance (achievement strategy), even in resource shortage, along with goal achievement, contributes to a favorable mental state. On the contrary, resource-saving (avoidance strategy) leads both to failure in achieving goals and to depletion of resources, as well as to a deterioration in mental state (Shapkin, 1999).

On the whole, despite a large number of investigations on cognitive functioning under stress, there is a lack of studies on samples of professionals or future professionals whose professional activity would be related to stress factors of extreme intensity. We assume that rescuers would attain an optimal functional state under stress, which is defined by L. G. Dikaya and V. I. Shchedrov as 'productive tension'. Stress resistance of memory capacity might be one of such productive state manifestations. In terms of motivation, this is associated with the purposeful character of actions while performing professional tasks. More generally, it is essential to mention the system of screening and psychological training of fire cadets in the Academy of State Fire Service. This general assumption is specified in the following hypotheses of the present study: stress increases short-term memory capacity in fire cadets whose professional activities will be related to emergencies.

Methods

Study participants

A total of 97 responders participated in the study. The analysis did not include data for 7 subjects (3 cadets and 4 students). Thus, we analyzed the data from the sample of 90 responders, including 50 fire cadets of the Academy of State Fire Service and 40 students of Moscow universities: Lomonosov Moscow State University, Russian Foreign Trade Academy, Kutafin Moscow State Law University), studying in various specialties: geography, geology, economics, jurisprudence, etc. The experimental group comprised 30 fire cadets: 15 males, 15 females aged 21 to 24 years. The other participants were randomized in 3 groups of comparison. Table 1 provides detailed age and gender characteristics for all the study participants.

Study Procedure

The study involved four groups of respondents tested at baseline and at the end of the study. Table 1 shows the experiment design.

Table 1
The experiment design and characteristics of respondents

Fire cadets, n = 50	Baseline assessments of the short-term memory (1st series of stimuli, Digit Span Test)	Under stress	Group 1, 30 respondents: 15 males, 15 females aged 21 to 24 (M = 21.8)	Final assessments of short-term memory (2nd series of stimuli Digit Span Test)
		No stress	Group 2, 20 respondents: 10 males, 10 females aged 22 to 24 (M = 21.5)	
Students, n = 40		Under stress	Group 3, 20 respondents: 10 males, 10 females aged 19 to 24 (M = 21.3)	
		No stress	Group 4, 20 respondents: 10 males, 10 females aged 20 to 23 (M = 21.6)	

Respondents in experimental groups were given stressful photo and audio materials. Photo content included on-the-spot pictures of emergencies, bodies of victims, fire accidents, buildings thrown down by earthquakes. In addition to such photos, we presented images with poisonous insects, blood, injection syringes, and needles. Stressful audio content included records of human cries, sound of sirens, baying of dogs, and whipping of children.

Pictures with stressful photo content were presented for 2 minutes before the final short-term memory assessments; at the same time, sounds were transmitted to respondents via headphones. Sounds kept being transmitted during the final assessment procedure (Table 2).

Besides, we presented a neutral video content with images of nature: at the first stage of the study (for one minute) to assess baseline physiological parameters in the initial calm state; at the second or third and final stages of the study (for one minute, as well) a similar video content was presented for relaxation (Table 2).

Table 2
Study Procedure

Stages of the study	Groups without stress		Groups under stress		
1	Neutral video content	Physiological state measurement	Neutral video content	Physiological state measurement	
2	Digit Span Test	Physiological state measurement	Digit Span Test	Physiological state measurement	
3	Neutral video content		Neutral video content		
4	–		Stressful photo and audio content		
5	Digit Span Test	Physiological state measurement	Stressful audio content	Digit Span Test	Physiological state measurement
6	Neutral video content		Neutral video content		

All the respondents were informed that they would take part in the study of memory using stressful content. They were, furthermore, informed on the possibility of withdrawing from the study at any time during the experiment, in case it becomes annoying or uneasy. The experiment participants were also informed that we might use their results in a generalized form. None of our respondents refused to participate in the study.

Assessment of the physiological state of study subjects

The physiological state of study subjects was assessed using biological feedback (Reacor BFB). The biofeedback system included: a computer (to monitor and control the procedure progress), a patient display (to present visual stimuli), a Reacor patient block (comprises four general polygraph channels), and sensors set to record physiological signals.

Using BFB, we evaluated whether the subjects exposed to stressful stimuli were in a state of physiological tension (arousal) and whether the subjects from the groups without stressful stimuli exposure were in a neutral (quiet) state. For that purpose, we recorded physiological parameters throughout the whole experiment time; after that, we compared the data representing physiological parameters collected at three stages of the study. Table 2 summarizes the study procedure at all the stages.

During the study, we recorded the following physiological parameters: heart rate, circumflex electromyogram (CEMG), *systolic wave* amplitudes, and the pulse transit time from the heart to

Russian Psychological Journal, 2020, Vol. 17, No. 1, 27–43. **doi**: 10.21702/rpj.2020.1.3

the periphery (PTTHP) were registered using the photoplethysmography (volumetric blood flow). The significant difference in two or more of the mentioned parameters suggested that the participant was in a state of physical tension. Heart rate was measured using electrocardiography (ECG) as a number of heartbeats per minute. The heart rhythm was recorded using sensors with clip electrodes placed on radial arteries of arms. A neutral electrode was used, as well. Also, to evaluate the physiological state with the circumplex electromyography (CEMG), electric signals due to the muscular contractions of trapezius muscle were recorded.

Seven subjects from the 1st and the 3rd groups, exposed to stressful factors, were excluded from the further analysis (3 cadets and 4 students) due to the lack of signs of physiological tension state, according to the measurement results. All other participants from the groups with stress were in a state of physiological tension. Meanwhile, participants from the groups without stress did not show signs of tension.

Short-term memory measurement

Baseline and final assessments of short-term memory capacity were carried out using the Digit Span Test, where respondents were presented with numerical series gradually increasing in a number of characters (Jones & Macken, 2015). Different numerical series were used for assessments in groups with and without stress. An example of stimuli is presented below (Fig. 1).

The following instructions were given to subjects on display: 'Random numerical series containing from 4 to 10 elements will be presented to you on display, starting with the shortest. When the display turns green, please, immediately say aloud the numbers in the order, they were demonstrated'.

Baseline assessment 1st Digit Span Test series presentation		Final assessment 2nd Digit Span Test series presentation	
1st presentation		1st presentation	
1.	2587	1.	1540
2.	48752	2.	65742
3.	951236	3.	274918
4.	7541238	4.	9546320
5.	74125895	5.	45157621
6.	105786428	6.	628741038
7.	4582168732	7.	7514682054
2nd presentation		2nd presentation	
1.	8542	1.	4928
2.	75423	2.	86547
3.	158634	3.	105682
4.	2690267	4.	4210856
5.	95486327	5.	84751026
6.	791742250	6.	359405482
7.	3521404861	7.	1815497201

Figure 1. Digit Span Test, presented to participants

Data processing procedure

We calculated short-term memory capacity using the following equation: $V = A + \frac{m}{n}$, where V is short-term memory capacity; A – the longest numerical series reproduced correctly in all presentations; m – number of correctly reproduced numerical series longer than A; n – number of series (here, n = 2). We analyzed only those numerical series that were reproduced correctly in due order.

Obtained data were processed using the IBM SPSS Statistics, Version 22. We used the Kruskal–Wallis H test, Wilcoxon match-pairs rank test, Mann–Whitney U test, Spearman's rho test, and Cohen's effect size d-coefficient. The effect sizes were determined as small (d = 0.2), medium (d = 0.5), and large (d = 0.8) (Cohen, 1988).

Results

In the first series of the Digit Span Test under neutral conditions, the obtained results were comparable in all the four groups (Kruskal–Wallis H test: H = 3.374; p = 0.337).

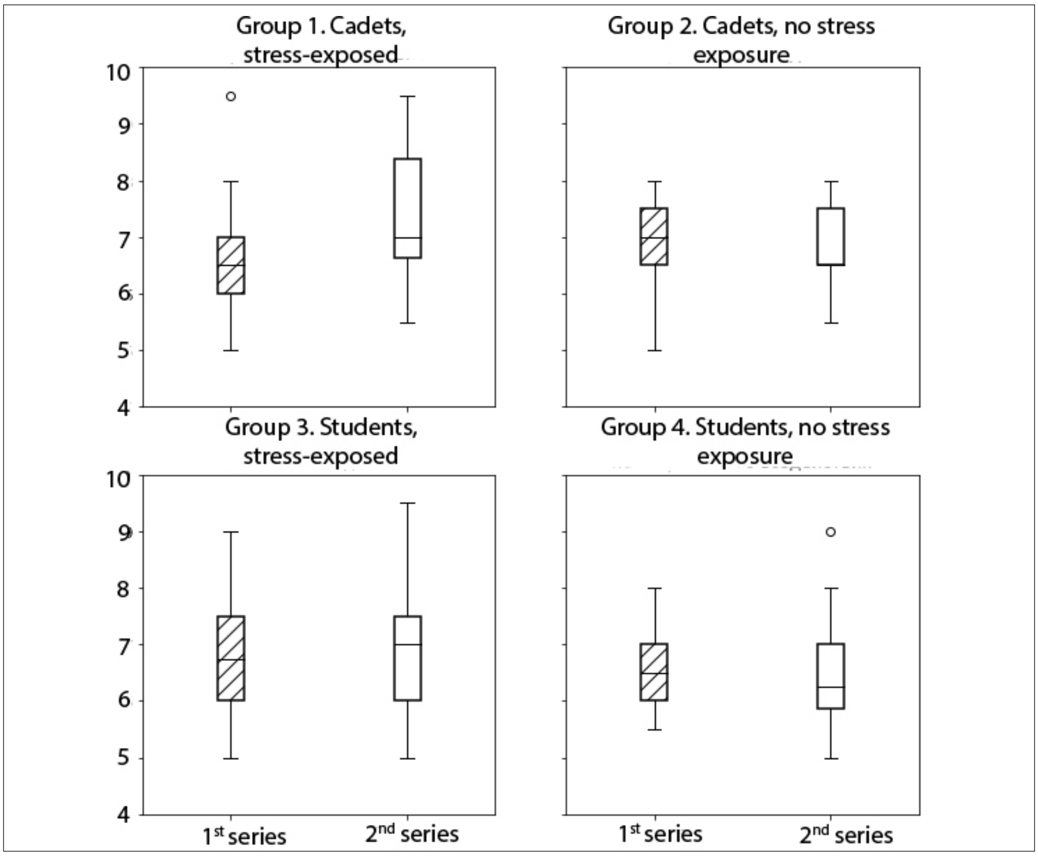

Figure 2. Median and interquartile ranges in the 1st and 2nd series of the Digit Span Test for each group

Vertical: Short-term memory capacity. Horizontal: Results of the 1st and 2nd series of the Digit Span Test

Digit Span Test diagnostic findings are summarized in Table 3 and Figure 2, were results of the 1st and the 2nd series of tests are compared for each study group separately. Findings from the 2nd series indicated that fire cadets had better results when carrying out the Digit Span Test under stress (Wilcoxon match-pairs rank test, $p = 0.001$). According to Cohen's effect size d-coefficient, the obtained effect size was medium ($d = 0.7232$). Learning cannot explain these results, as the fire cadets carrying out the Digit Span Test without stress for the second time did not improve their results.

Table 3
Digit Span Test results for each group of participants

Descriptive statistics	1st series (Digit Span Test)			2nd series (Digit Span Test)			Difference between series	Wilcoxon match-pairs rank test (the difference between 1st and 2nd series))	
	M	SE	SD	M	SE	SD	M	z	p
Group 1.Fire cadets, under stress	**6,53**	0,17	0,96	**7,30**	0,21	1,16	0,77	–3,265	**0,001**
Group 2. Fire cadets, no stress	6,88	0,16	0,70	6,78	0,16	0,73	–0,10	–0,485	0,628
Group 3. Students, under stress	6,78	0,23	1,02	6,70	0,23	1,04	–0,08	–0,751	0,452
Group 4. Students, no stress	6,60	0,16	0,74	6,50	0,23	1,03	–0,10	–0,605	0,545

Table 4
Generalized data of the Digit Span Test

Changes in short-term memory capacity, 2nd series of the test	Group 1. Fire cadets, under stress		Group 2. Fire cadets, no stress		Group 3. Students, under stress		Group 4. Students, no stress	
	Qty	Qty (%)	Qty	Qty (%)	Qty	Qty (%)	Qty	Qty (%)
Short-term memory capacity increased	20	66.67	5	25	5	25	7	35
No changes	4	13.33	8	40	7	35	6	30
Short-term memory capacity decreased	6	20	7	35	8	40	7	35

We observed a non-significant decrease of results by the memorizing test in students of both groups (under stress and with no stress) and in fire cadets from the 2nd group (without stress). No difference between males and females was found.

Table 4 shows the generalized data demonstrating intragroup changes in short-term memory capacity in the 2nd series of the study compared to the 1st one. We should note that in the experimental group of cadets, carrying out the 2nd Digit Span Test series under stress (group1), short-term memory capacity was increased in 66.7 % of respondents and decreased in 20 % of them; 13.3 % of cadets had no changes in short-term memory capacity. We obtained the following results in the second group of cadets (without stress): short-term memory capacity was increased in 25 % of respondents and decreased in 35 % of them; 40 % of respondents had no changes in short-term memory capacity.

In the third group (students under stress), short-term memory capacity was increased in 25 % of respondents and decreased in 40 % of them; 35 % of respondents had no changes in short-term memory capacity. In the fourth group (students without stress), the equal proportion of respondents (35 %) demonstrated a decrease and an increase in short-term memory capacity in the 2nd series of the test; 30 % of respondents had no changes in short-term memory capacity.

Tables 5 and 6 provide the data for physiological parameters in two groups of respondents exposed to the stressful factors at three stages of the experiment. Students demonstrated higher baseline muscular tension compared to fire cadets ($z = -1.99$; $p = 0.047$; Cohen's d-coefficient = 0.669). Systolic wave amplitude measures (blood flow measurements in small vessels) during the 1st series of the Digit Span Test ($z = -2.222$; $p = 0.026$; Cohen's d-coefficient = 1.41) and the pulse transit time in cadets were lower ($z = -2.743$; $p = 0.006$; Cohen's d-coefficient = 0.665) compared to students; during the 2nd series of the Digit Span Test pulse transit time measures were also lower in cadets ($z = -2.278$; $p = 0.023$; Cohen's d-coefficient = 0.6605). However, the analysis of differences in the state measures under neutral vs. stressful conditions demonstrated that SWA measures changed more pronouncedly in students ($z = -2.131$; $p = 0.033$) compared to cadets.

Table 5

Physiological parameters in fire cadets and students in exposure groups (group 1 and group 3) at different stages of the study

Stages	ECG – I; HR (beats/min)			Finger L; SWA (pm)			Finger L; PTT (msec)			FL; EMG (uV)		
	M	M ± SD		M	M ± SD		M	M ± SD		M	M ± SD	
		LL	UL		LL	UL		LL	UL		LL	UL
Baseline, fire cadets	88.57	66.40	110.73	0.53	0.31	0.75	185.04	151.68	218.40	7.84	4.24	10.44
Baseline, students	86.05	72.42	100.67	1.06	0.56	1.56	198.75	172.97	224.54	11.10	8.26	13.89
Digit Span Test, neutral conditions, fire cadets	88.15	78.29	98.01	0.53	0.42	0.64	181.13	165.45	196.81	7.95	5.10	10.14
Digit Span Test, neutral conditions, students	91.7	81.48	99.17	1.29	0.75	1.83	197.24	167.99	226.50	10.51	8.21	12.82

Table 5
Physiological parameters in fire cadets and students in exposure groups (group 1 and group 3) at different stages of the study

Stages	ECG – I; HR (beats/min)			Finger L; SWA (pm)			Finger L; PTT (msec)			FL; EMG (uV)		
	M	M ± SD		M	M ± SD		M	M ± SD		M	M ± SD	
		LL	UL		LL	UL		LL	UL		LL	UL
Digit Span Test, stress exposure, fire cadets	113.80	95.00	132.94	0.30	0.15	0.45	167.97	142.95	192.65	23.76	20.20	27.33
Digit Span Test, stress exposure, students	117.56	101.23	133.33	0.52	0.16	0.89	180.24	153.82	206.17	27.79	24.95	29.54

Notes: EKG – electrocardiography: *HR* – heart rate; *SWA* – systolic wave amplitude; *PTT* – pulse transit time; *EMG* – electromyography; *M* – mean; *SD* – standard deviation; *LL* – lower limit; *UL* – upper limit.

Table 6
Differences in physiological parameters between fire cadets and students in the stress exposed groups

	Cadets	Students	Mann–Whitney U test	Z	Asymptotic significance levels (two-tailed)
Delta 1 Heart Rate, M	–0.41	5.03	191.000	–2.159	0.031
Delta 1 SWA, M	0.00	0.23	227.500	–1.438	0.151

Table 6
Differences in physiological parameters between fire cadets and students in the stress exposed groups

	Cadets	Students	Mann–Whitney U test	Z	Asymptotic significance levels (two-tailed)
Delta 1 PTT, M	–3.91	–1.51	249.000	–1.010	0.313
Delta 1 EMG, M	0.12	–0.59	254.500	–0.901	0.368
Delta 2 Heart Rate, M	25.65	26.48	296.000	–0.079	0.937
Delta 2 SWA, M	–0.23	–0.77	192.500	–2.131	**0.033**
Delta 2 PTT, M	–13.16	–17.00	300.000	0.000	1.000
Delta 2 EMG, M	15.81	17.28	269.000	–0.614	0.539

Notes: Delta 1 – the difference between baseline findings and the 1st series of the Digit Span Test under neutral conditions; *Delta 2* – the difference between 1st and 2nd series of the Digit Span Test (memorizing under neutral or stressful conditions).

Discussion

Our hypothesis was partly confirmed: compared to memory capacity measured under neutral conditions, stress exposure caused an increase in the capacity of short-term memory in 67 % of fire cadets. Thus, the obtained results suggest that the majority of cadets may increase their cognitive activity under stress. These findings agree with other studies of the inverse U-shaped curve between physiological tension and performance efficiency, where it was shown that a moderate amount of stress exposure exerts a mobilizing effect (Easterbrook, 1959; McGaugh, 2006; Hancock & Weaver, 2005). Further, we would like to try to explain differences in results obtained in the groups of cadets and students. There are some possible explanations:

1. The two groups could be at different levels of the inverse U-shaped curve. This level could be moderate for fire cadets, which resulted in less pronounced physiological responses and better memorizing, and high for students, which, however, did not lead to a decrease in the memory performance. Table 5 shows that physiological responses differed in fire cadets and students; this difference requires more detailed consideration. Thus, our findings indicate that already during the 1st Digit Span Test series, the cadets were mobilized. That is why the small vessel circulation measures did not drastically change during the 2nd series of test, as it was observed among the students.

2. There is a difference in the motivational and emotional regulation of an aroused physiological state. Fire cadets are able to maintain their cognitive performance at a high level under stress. In terms of motivation, it is associated with the purposefulness of activity, desire to help others, and save lives. In terms of professional competences, it is associated with optimism, positive self-appraisal, and vigor (as components of the appraisal of a situation as a 'challenge'). Moreover, to solve these tasks, cadets were prequalified with medical and psychological screening. They also train themselves to keep calm when performing motor or cognitive tasks under stress (Bityutskaya, Eliseeva, & Shoigu, 2015). Therefore, compared to students, cadets may be more inclined to active problem-solving under stressful conditions (Gurenkova et al., 2007).

While the majority of fire cadets had increased short-term memory capacity, it was decreased in 20 % of cadets; 13 % of cadets had no changes in short-term memory capacity. To explain this fact, we carried out an extension study. In so doing, we based upon the research of self-regulation, which considered short-term memory functions in their associations with intelligence and thinking (Barrett et al., 2004; Velichkovskii, 2016). We analyzed correlations between non-verbal intelligence levels of fire cadets, measured using the *Raven's Progressive Matrices* test, and the results of the 2nd Digit Span Test series. Spearman's rho test was 0.585 ($p = 0.01$). The group of fire cadets who demonstrated an *increase* in short-term memory capacity under stress included those with average levels of intelligence (5 %), above-average levels of intelligence (55 %), and high levels of intelligence (40 %). The majority of fire cadets with *decreased* or *unchanged* short-term memory capacity (60 %) had average levels of intelligence; 30% of them had below-average levels of intelligence. 10 % of fire cadets with *decreased* or *unchanged* short-term memory capacity had high levels of intelligence. This analysis suggests that self-regulation efficiency in stressful situations may be considered in terms of both short-term memory functioning and intellectual characteristics.

Conclusion

The findings from this study of changes in short-term memory capacity under stressful conditions indicated that short-term memory capacity was increased in 67 % of fire cadets and decreased in 20 % of them; 13 % of fire cadets had no changes in short-term memory capacity.

For a more detailed assessment of physiological states of respondents under stressful conditions, further researches in this field should use additional methods, such as the assessment of salivary cortisol.

References

Bargh, J. A., & Cohen, J. L. (1978). Mediating factors in the arousal-performance relationship. *Motivation and Emotion*, *2*, 243–257. doi: 10.1007/BF00992589

Barrett, L. F., Tugade, M. M., & Engle, R. W. (2004). Individual differences in working memory capacity and dual-process theories of the mind. *Psychological Bulletin*, *130*(4), 553–573. doi: 10.1037/0033-2909.130.4.553

Bityutskaya, E. V., Eliseeva, I. N., & Shoigu, Yu. S. (2015). To the question of psychological mechanisms of rescuers training for professional activities. In V. T. Kudryavtsev (Ed.), *Education and Development: Modern Theory and Practice: Materials of the XVI International Readings in Memory of L. S. Vygotsky*. Moscow, November 20, 2015: At 2 p.m. Part 1 (pp. 240–244). Moscow: Lev. (in Russ.).

Blascovich, J., & Tomaka, J. (1996). The biopsychosocial model of arousal regulation. *Advances in Experimental Social Psychology*, *28*, 1–51. doi: 10.1016/S0065-2601(08)60235-X

Bodrov, V. A., & Oboznov, A. A. (2000). The system of mental regulation of stress tolerance of a human operator. *Psikhologicheskii zhurnal (Psychological Journal)*, *21*(4), 32–40. (in Russ.).

Bonanno, G. A., Papa, A., Lalande, K., Westphal, M., & Coifman, K. (2004). The importance of being flexible: The ability to both enhance and suppress emotional expression predicts long-term adjustment. *Psychological Science*, *15*(7), 482–487. doi: 10.1111/j.0956-7976.2004.00705.x

Buchanan, T. W., & Lovallo, W. R. (2001). Enhanced memory for emotional material following stress-level cortisol treatment in humans. *Psychoneuroendocrinology*, *26*(3), 307–317. doi: 10.1016/s0306-4530(00)00058-5

Buchanan, T. W., Tranel, D., & Adolphs, R. (2006). Impaired memory retrieval correlates with individual differences in cortisol response but not autonomic response. *Learning & Memory*, *13*, 382–387. doi: 10.1101/lm.206306

Cahill, L., Gorski, L., & Le, K. (2003). Enhanced human memory consolidation with post-learning stress: Interaction with the degree of arousal at encoding. *Learning & Memory*, *10*, 270–274. doi: 10.1101/lm.62403

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Crum, A. J., Salovey, P., & Achor, S. (2013). Rethinking stress: The role of mindsets in determining the stress response. *Journal of Personality and Social Psychology*, *104*(4), 716–733. doi: 10.1037/a0031201

Dikaya, L. G. (1999). System-activity concept of self-regulation of the psychophysiological state of a person. In L. G. Dikaya (Ed.), *Theory and methods of psychological analysis* (pp. 80–106). Moscow: Institute of Psychology RAS. (in Russ.).

Dikaya, L. G., & Shchedrov, V. I. (1999). A method for determining the individual style of self-regulation of a person's mental state. In L. G. Dikaya (Ed.), *Theory and methods of psychological analysis* (pp. 106–132). Moscow: Institute of Psychology RAS. (in Russ.).

Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review*, *66*(3), 183–201. doi: 10.1037/h0047707

Gurenkova, T. N., Eliseeva, I. N., Kuznetsova, T. Yu., Makarova, O. L., Matafonova, T. Yu., Pavlova, M. V., & Shoigu, Yu. S. (2007). In Yu. S. Shoigu (Ed.), *Psychology of extreme situations for rescuers and firefighters*. Moscow: Smysl. (in Russ.).

Hancock, P. A., & Weaver, J. L. (2005). On time distortion under stress. *Theoretical Issues in Ergonomics Science*, *6*(2), 193–211. doi: 10.1080/14639220512331325747

Hase, A., O'Brien, J., Moore, L. J., & Freeman, P. (2019). The relationship between challenge and threat states and performance: A systematic review. *Sport, Exercise, and Performance Psychology*, *8*(2), 123–144. doi: 10.1037/spy0000132

Jamieson, J. P., Mendes, W. B., Blackstock, E., & Schmader, T. (2010). Turning the knots in your stomach into bows: Reappraising arousal improves performance on the GRE. *Journal of Experimental Social Psychology*, *46*(1), 208–212. doi: 10.1016/j.jesp.2009.08.015

Jones, G., & Macken, B. (2015). Questioning short-term memory and its measurement: Why digit span measures long-term associative learning. *Cognition*, 144, 1–13. doi: 10.1016/j.cognition.2015.07.009

Lazarus, R. S. (1991). Progress on a cognitive-motivational-relational theory of emotion. *American Psychologist*, *46*(8), 819–834. doi: 10.1037/0003-066x.46.8.819

Leonova, A. B., & Kuznetsova, A. S. (2015). Functional conditions and human performance in professional activities. In E. A. Klimov, O. G. Noskova, G. N. Solntseva (Eds.), *Labor Psychology, Engineering Psychology and Ergonomics* (pp. 319–346). Moscow: Yurayt. (in Russ.).

Levine, L. J., & Burgess, S. L. (1997). Beyond general arousal: Effects of specific emotions on memory. *Social Cognition*, *15*(3), 157–181. doi: 10.1521/soco.1997.15.3.157

Levine, L. J., & Pizarro, D. A. (2004). Emotion and memory research: A grumpy overview. *Social Cognition*, *22*(5), 530–554. doi: 10.1521/soco.22.5.530.50767

Mather, M. (2007). Emotional arousal and memory binding: An object-based framework. *Perspectives on Psychological Science*, *2*(1), 33–52. doi: 10.1111/j.1745-6916.2007.00028.x

McGaugh, J. L. (2006). Make mild moments memorable: add a little arousal. *Trends in Cognitive Sciences*, *10*(8), 345–347. doi: 10.1016/j.tics.2006.06.001

Shapkin, S. A. (1999). A technique for studying strategies for adapting a person to the stressful conditions of professional activity. A method for determining the individual style of self-regulation of a person's mental state. In L. G. Dikaya (Ed.), *Theory and methods of psychological analysis* (pp. 132–165). Moscow: Institute of Psychology RAS. (in Russ.).

Sharot, T., & Phelps, E. A. (2004). How arousal modulates memory: Disentangling the effects of attention and retention. *Cognitive, Affective, & Behavioral Neuroscience*, *4*, 294–306. doi: 10.3758/cabn.4.3.294

Tomaka, J., Blascovich, J., Kelsey, R. M., & Leitten, C. L. (1993). Subjective, physiological, and behavioral effects of threat and challenge appraisal. *Journal of Personality and Social Psychology*, *65*(2), 248–260. doi: 10.1037/0022-3514.65.2.248

Velichkovsky, B. B. (2016). The influence of working memory on the effectiveness of self-regulation of behavior and coping. In T. L. Kryukova, M. V. Saporovskaya, S. A. Khazova (Eds.), *Psychology of stress and coping behavior: resources, health, development: Materials of the IV Intern. Scientific conf*. Kostroma, September 22–24. 2016: In 2 volumes (pp. 25–27). Kostroma: KSU named after N. A. Nekrasov. (in Russ.).

Vine, S. J., Freeman, P., Moore, L. J., Chandra-Ramanan, R., & Wilson, M. R. (2013). Evaluating stress as a challenge is associated with superior attentional control and motor skill performance: Testing the predictions of the biopsychosocial model of challenge and threat. *Journal of Experimental Psychology: Applied*, *19*(3), 185–194. doi: 10.1037/a0034106

Vine, S. J., Uiga, L., Lavric, A., Moore, L. J., Tsaneva-Atanasova, K., & Wilson, M. R. (2015). Individual reactions to stress predict performance during a critical aviation incident. *Anxiety, Stress, & Coping*, *28*(4), 467–477. doi: 10.1080/10615806.2014.986722

Russian Psychological Journal, 2020, Vol. 17, No. 1, 27–43. **doi**: 10.21702/rpj.2020.1.3

Zotov, M. V. (2011). *The mechanisms of regulation of cognitive activity in conditions of arousal*. St. Petersburg: Rech'. (in Russ.).

No conflict of interest