# Asthenia—Does It Exist in Space?

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**Objective:** First popularized as neurasthenia in the late 1800s by American George Beard, asthenia has been viewed by Russian psychologists and flight surgeons as a major problem that affects cosmonauts participating in long-duration space missions. However, there is some controversy about whether this syndrome exists in space; this controversy is attributable in part to the fact that it is not recognized in the current American psychiatric diagnostic system. **Methods:** To address this issue empirically, we retrospectively examined the data from our 4 1/2-year, NASA-funded study of crew member and mission control interactions during the Shuttle/Mir space program. Three of the authors identified eight items of stage 1 asthenia from one of our measures, the Profile of Mood States (POMS). Scores on these items from 13 Russian and American crew members were compared with scores derived from the opinions of six Russian space experts. **Results:** Crew members' scores in space were significantly lower than the experts' scores on seven of the eight items, and they generally were in the "not at all" to "a little" range of the item scales. There were no differences in mean scores before and after launch or across the four quarters of the missions. There were no differences in response between Russian and American crew members. **Conclusions:** We could not demonstrate the presence of asthenia in space as operationally defined using the POMS. However, the POMS addresses only emotional and not physiological aspects of the syndrome, and the subject responses in our study generally were skewed toward the positive end of the scales. Further research on this syndrome needs to be done and should include physiological measures and measures that are specific to asthenia. **Key words:** asthenia, neurasthenia, psychosomatic, space, astronaut, cosmonaut.

APA = American Psychiatric Association; NASA = National Aeronautics and Space Administration; POMS = Profile of Mood States.

## INTRODUCTION

Psychosomatic symptoms have been reported anecdotally during space missions, especially by Russian cosmonauts who have been on orbit in the Salyut and Mir space stations for several months. For example, in his diary a Salyut 6 cosmonaut described a fear of having an appendicitis attack in space, and he experienced pain in his teeth after having a dream of a toothache (1). A Salyut 7 cosmonaut had his mission terminated early because of fatigue, listlessness, and psychosomatic worries over perceived prostatitis and fears of impotence (2). A Mir cosmonaut experienced fatigue, physical complaints, and cardiac arrhythmias due to stressful events that resulted in a change in his work duties and the prescription of sedatives (3). Psychosomatic symptoms also have been reported in space analog environments, such as the Antarctic (4, 5) and submarines (6).

According to Russian psychologists and flight surgeons, one of the biggest problems affecting the emotional state of cosmonauts during long-duration space missions is asthenia (also called neurasthenia in some references). On Earth this syndrome is defined as a "nervous or mental weakness manifesting itself in tiredness. . .and quick loss of strength, low sensation threshold, extremely unstable moods, and sleep disturbance. [Asthenia] may be caused by somatic disease as well as by excessive mental or physical strain, prolonged negative emotional experience or conflict" (7, p. 28).

Russian experts diagnose and monitor asthenia in space through an analysis of the verbal communication between crew members and mission control; through an examination of medical information; and through an assessment of scales that address fatigue, somatic symptoms, sleep quality, and mood. The Russian literature suggests that elements of the syndrome commonly occur in cosmonauts who participate in space missions lasting more than a few weeks (8–15).

Symptoms and signs suggestive of asthenia also have been reported anecdotally in American astronauts who have flown in space during long-duration Skylab and Mir missions (2, 16, 17). Whether these episodes represent the true syndrome is open to debate, because neither asthenia nor neurasthenia is listed as a diagnostic entity in the latest edition of the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV) (18). This means that US mental health professionals can-

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not diagnose asthenia in their patients using the official APA nomenclature, and many of its symptoms and signs are subsumed under such diagnoses as adjustment, dysthymic, or major depressive disorders, or chronic fatigue syndrome.

### The Influence of George Beard

Ironically, the roots of asthenia can be traced back to the writings of an American, George Beard, who lived from 1839 to 1883. He observed that many of his patients complained of vague symptoms that included profound exhaustion, morbid fears and anxieties, hopelessness, mental irritability, inability to concentrate, forgetfulness, headaches, insomnia or bad dreams, physical ailments, body pains, and sexual difficulties. He believed that an underlying disorder was responsible for this plethora of symptoms, which he characterized as nervous exhaustion or neurasthenia as early as 1869 and subsequently in several editions of his book (19, 20). Although he believed that there were underlying anatomical causes of this condition that had yet to be discovered, none were known at the time, so he characterized neurasthenia as a functional disease, which in his day meant due to some physiological process (21).

Beard conceptualized the nervous system as a closed channel containing a fixed amount of nervous force that was determined by hereditary factors. Mental or physical strain or a primary weakness of the nervous system could cause a physical illness almost anywhere in the body through reflex irritation mediated by the nervous system, thus accounting for the variety and abundance of symptoms. Furthermore, nervous exhaustion could be caused by excessive environmental pressures, particularly from the kind of competitive and unstable society he saw in 19th century America that put excessive demands on people. In fact, Beard viewed neurasthenia as a peculiarly American disease that especially affected the upper classes. He outlined many treatments for neurasthenia, including diets and herbs, medications, rest, massage, and local applications of electricity.

Although some of Beard's contemporaries did not accept his ideas and were put off by his self-promotion and "fashionable self-indulgence" (21), the concept of neurasthenia gradually took hold and spread to Europe, especially France and Russia (19). Sigmund Freud separated anxiety neurosis from neurasthenia, with the former being characterized by excessive amounts of sexual energy and the latter by depletions of sexual energy through excessive discharge (22). After World War I, the concept of neurasthenia declined in the United States, although it remained popular in other countries (19). The diagnosis still appears in the *International Classification of Diseases, 9th Revision* (ICD-9-CM) as follows: "300.5 Neurasthenia. Def: A pattern of physical and mental symptoms caused primarily by what is known as mental exhaustion; symptoms include chronic weakness and fatigue. . .[also called]. . .Fatigue neurosis, Nervous debility, Psychogenic asthenia, Psychogenic general fatigue" (23, p. 224).

### Russian Descriptions of Asthenia in Space

Myasnikov and Zamaletdinov (8) state that elements of asthenia, such as fatigue, emotional lability, and sleep disturbances, are seen in cosmonauts participating in space missions lasting more than 4 months. This has resulted in instances of impaired performance, crew member conflict, and operational errors. The condition seems to be one of cumulative fatigue that develops over time.

Aleksandrovskiy and Novikov (9) believe that a mild form of asthenia (ie, hyposthenia) develops in many cosmonauts after 1 to 2 months of flight, becoming severe in some cases. They view the hyposthenic state as one in which inhibitory processes predominate and as being characterized by increased fatigue, decreased work capacity, sleep disorders, anxiety and internal stress, autonomic disturbances (eg, palpitations and perspiration), attention and concentration difficulties, and heightened sensitivity to bright lights and loud noises. They believe that asthenic symptoms frequently occur after sudden life-threatening situations or episodes of emotional stress. They differentiate asthenia from depression, although they state that symptoms of the former may "supplement" the phenomenology of the latter.

In a questionnaire study of 54 astronauts and cosmonauts who had flown in space, Kelly and Kanas (24) found possible evidence of increased sensitivity to visual and auditory stimulation, as mentioned above by Aleksandrovskiy and Novikov. On items assessing changes in a number of activities, the subjects reported that watching and listening activities significantly increased in space during both work and leisure time periods. This was reminiscent of reports that during Salyut 6 and 7, changes in perceptual sensitivities were noted after 3 to 5 months, with some cosmonauts becoming increasingly disturbed by loud sounds and the manner of verbal presentations from people in mission control (10).

Aleksandrovskiy has described three stages of asthenia (11). In the first stage (hyperesthesia), there is a general increase in sensitivity to external stimuli, resulting in hyperarousal and increased (sometimes pointless) activity, emotional instability and irritability, impatience, decreased memory, poor attention and concentration, fatigue, headaches, perspiration, instability of pulse and blood pressure, and sleep disturbances. In the intermediate stage (irritable weakness), irritability and emotional instability progress into more severe fatigue, negative emotional reactions, and somnolence. In the third stage (hypoesthesia), there is indifference and inertness, apathy, constant fatigue, passiveness, and lack of work capability.

More recently, Myasnikov et al. (12) have described the symptoms of asthenia in space as being similar to those affecting patients on the ground, and both versions reflect de-adaptation to a stressful environment. They believe that asthenia in the clinical setting on Earth is a disorder with neurotic features, and it is treated with medications. However, asthenia in space usually is milder, in part because cosmonauts are carefully screened for psychiatric problems before being selected and in part because people in space are monitored and countermeasures are taken at the first sign of psychological difficulty. Consequently, medications usually are not needed. Asthenia in space is viewed as being at the "frontier" between health and disease, and it reflects both the level of psychological stress during space missions and the inadequacy of individual coping strategies. For these reasons, the authors prefer the term "psychic asthenization" when referring to the syndrome in space. They summarize: "We classify negative changes in the psychological state of cosmonauts as signs of psychic asthenization, which can be regarded as a way of adapting and disappear some time after the flight" (12, p. 71).

Countermeasures used by Russian psychologists and flight surgeons to deal with the signs and symptoms of asthenia in space include reorganizing work schedules to allow for more leisure time activities; scheduling difficult job tasks in the morning rather than right before bedtime; limiting nonessential contact with mission control personnel; encouraging physical activities to enhance normal physiological responses; sending up surprise presents and favorite foods on re-supply spacecraft to provide novelty and stimulation; and improving morale by increasing audiovisual contact with friends, relatives, and famous personalities on Earth (8, 9, 13, 14). In the Kelly and Kanas questionnaire study, the respondents reported that contact with loved ones on the ground had a significantly positive influence on their performance, especially Russian cosmonauts and space travelers who had spent a total of 20 or more days in space (25). These two groups also were more sensitive to the absence of letters and other forms of contact with people on Earth than non-Russian astronauts and people spending less than 20 days in space (26).

### The Shuttle/Mir Program

The above clinical, operational, and empirical evidence suggests that asthenia may occur in the space environment. We were interested in exploring whether we could find empirical evidence for this syndrome during actual space missions. To do this, we retrospectively examined the data from our 4 1/2-year, NASA-funded study of crew member and mission control personnel during the Shuttle/Mir space program.

This program has been construed as the phase 1 pathfinder for the International Space Station (the construction and operation of which are referred to as phases 2 and 3, respectively). Shuttle/Mir provided an opportunity for American astronauts and Russian cosmonauts to work together in space for long periods of time. Altogether, 7 Americans and 17 Russians participated in this program over a span of 4 years (27).

Although US and Russian launches to the Mir were staggered in time, typically there was one American and two Russians on board, with the commander always being a cosmonaut. Operational decisions involving the spacecraft generally took place in the Russian language between the cosmonauts and mission control in Moscow. On-board activities involved both Americans and Russians and included routine maintenance of the Mir, material and life sciences research, Earth observation studies, space walks, and exercise and physical conditioning (16, 17, 27). The crew members worked the same shift, and time was set aside for them to eat together and to engage in leisure activities that included television downlinks and e-mail with family and friends on Earth. However, frequent breakdowns of vital equipment on the Mir (eg, oxygen generator and coolant system), along with two life-threatening accidents (an on-board fire and a collision with a Progress re-supply spacecraft), led to stressful periods of time that involved many of the crew members and threatened possible evacuation of the Mir. But in general these issues were resolved and mission goals were accomplished.

## METHODS

### Subjects

Our funded study period included a total of five American and four Russian missions. The subjects who volunteered and participated in the study during the on-orbit period were 5 astronauts, 8 cosmonauts, and 42 American and 16 Russian mission control personnel, who included flight surgeons, operations leads, engineers, mission scientists, "capcoms" (spacecraft communicators), and psychological support staff. Because of confidentiality considerations resulting from the relatively small number of crew member subjects, no further demographic information was obtained to protect the identity of the subjects. US crew members who participated in our study were in space for a mean of 17.8 weeks (range = 17–19 weeks), and our cosmonaut subjects were in space for a mean of 27.0 weeks (range = 25–29 weeks). We tested a number of hypotheses related to crew member and mission control tension, cohesion, leader support, and in-group/out-group displacement of dysphoric emotions; these results are reported elsewhere (28–31).

### Measures

A number of standardized measures were used to test the study hypotheses, and they were packaged into a research questionnaire that was available in both English and Russian. The questionnaire was completed weekly on the same day of the week by all participants before, during, and after each mission. Crew members completed computerized versions on the Mir, and mission control subjects completed written versions on Earth. Overall, 82% of the expected questionnaires were received from the on-orbit period (70% from crew members and 85% from mission control personnel).

Our study was not designed to specifically assess asthenia, so to evaluate its presence in space among crew members, we reexamined the data from one of our questionnaire measures, the Profile of Mood States (POMS) (32). This measure consists of 65 adjectives describing various emotions that are rated by subjects as applied to their general affective state during the preceding week. Completing the POMS takes 5 to 10 minutes, and ratings are made on a five-point Likert scale: 0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, and 4 = extremely. Norms for the POMS have been established by data from more than 1000 psychiatric patients, 856 college students, and 2360 adults involved in a smoking cessation program. It has been shown to have good predictive and construct validity in studies of both patient and nonpatient groups and moderate to excellent concurrent validity with scales of the Hopkins Symptom Distress Scales, Taylor Manifest Anxiety Scale, Minnesota Multiphasic Personality Inventory (MMPI-2), and Beck Depression Scale. The standard POMS scales have shown internal consistency reliability coefficients near 0.90 and test-retest coefficients near 0.70 (32).

Three of the authors (N.K., V.G., and C.F.) independently examined the POMS to identify items characteristic of the first stage of asthenia. Because advanced asthenia in space would trigger a number of countermeasures from psychological support staff on the ground, we did not expect to see symptoms of the later stages of the syndrome, so we concentrated our efforts on finding elements of the first stage. Because the POMS consists only of emotional items, we could not directly evaluate all the characteristics of asthenia (eg, somatic problems like headaches and sleep disturbances). However, we could evaluate other important characteristics like degree of tension, irritability, cognition, and low energy. Eight items nominated by all three raters were selected as being characteristic of stage 1 asthenia: On Edge and Restless (tension items), Resentful and Annoyed (irritability items), Forgetful and Unable to Concentrate (cognition items), and Weary and Fatigued (low energy items). The weekly on-orbit data from the 13 crew members on these eight items were subjected to analysis for asthenia.

Another approach was implemented to assess asthenia using these eight items from the POMS. Six Russian space experts, who ranged in age from 40 to 60 years, who were familiar with the characteristics of asthenia, and who had worked directly with cosmonauts for 10 years or more, were instructed to complete a Russian translation of the POMS as if they were cosmonauts suffering from the first stage of asthenia. We were interested in comparing the POMS results from our subjects with the clinically meaningful prototype scores from the experts to see if this approach would yield evidence that might support the existence of the asthenic syndrome in space.

### Statistical Analysis

For each of the 13 crew members, the weekly ratings of each of the eight POMS items were averaged across all mission weeks. This procedure yielded a mean score for each item during the on-orbit period. For all of the POMS "asthenia" items, we used $t$ tests to assess for differences between the mean scores of crew members and Russian experts and for differences between the mean scores of Russian and American crew members.

To control for the inflated Type I error rate associated with multiple significance tests, the false discovery rate procedure developed by Benjamini and Hochberg (33) was used to determine an adjusted significance threshold. This procedure controls the expected proportion of falsely rejected null hypotheses (ie, the false discovery rate) and has some advantages (including more power) over Bonferroni-type procedures that control the family-wise error rate. To calculate an adjusted significance level threshold for each effect being evaluated, the actual $p$ values from the total number of items being tested ($N = 8$ in this case) were rank-ordered from smallest to largest. The rank number of each $p$ value was multiplied by 0.05, and the result was divided by 8. These new adjusted $p$ values then were compared with the corresponding original $p$ values until the first instance where the new value exceeded the old. This adjusted $p$ value then became the overall adjusted significance level threshold for that particular effect.

## RESULTS

We calculated Pearson correlations on the set of eight items completed by our 13 crew members. This yielded an overall mean correlation of 0.57. All of the items correlated positively with all of the others. The mean correlations of each item with the other seven items were as follows: Restless = 0.30, Unable to Concentrate = 0.44, Fatigued = 0.52, Weary = 0.55, Annoyed = 0.65, Resentful = 0.681, On Edge = 0.682, and Forgetful = 0.70.

Table 1 shows the mean on-orbit scores for the eight

**TABLE 1. Comparison of Shuttle/Mir Crew Member and Russian Space Expert Mean Scores on the "Asthenia" Items From the POMS[a]**

| POMS Item | Crew Members ($N = 13$) | | Russian Experts ($N = 6$) | | $t$ | $p$ | Effect Size |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | | |
| On edge | 0.25 | 0.38 | 2.50 | 0.84 | −6.29 | .001[b] | −8.40 |
| Restless | 0.39 | 0.83 | 1.00 | 1.26 | −1.27 | .220 | −1.74 |
| Resentful | 0.08 | 0.16 | 2.17 | 0.98 | −5.16 | .003[b] | −8.07 |
| Annoyed | 0.29 | 0.45 | 2.00 | 0.89 | −4.44 | .004[b] | −6.09 |
| Forgetful | 0.17 | 0.25 | 2.50 | 1.05 | −5.37 | .003[b] | −8.43 |
| Unable to concentrate | 0.05 | 0.10 | 1.83 | 0.75 | −5.77 | .002[b] | −7.96 |
| Weary | 0.42 | 0.46 | 2.33 | 0.82 | −6.60 | .000[b] | −6.96 |
| Fatigued | 0.59 | 0.42 | 2.67 | 0.52 | −9.27 | .000[b] | −8.85 |

[a] Scale anchoring points: 0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, and 4 = extremely.
[b] Value is less than the Benjamini and Hochberg (33) adjusted significance threshold of $p = .044$.

asthenia items from the crew members in our study along with the mean scores from the six experts. The crew member scores were significantly lower than the expert ratings from the constructed asthenia prototype on seven of the eight variables after correcting for Type I errors using the Benjamini and Hochberg procedure. As can be seen, the corresponding effect sizes were greater than 6. Only Restless yielded a nonsignificant result and a comparably smaller effect size. The crew member mean scores all were less than 1, putting them in the "not at all" to "a little" range of the POMS, whereas the mean scores for the expert prototype tended to be in the "a little" to "quite a bit" range. In addition, we used *t* tests to compare the crew member scores shown in Table 1 with their comparable scores obtained during 4 weeks of prelaunch training on Earth, and there were no significant differences on any of the eight POMS items. Taken together, the above results do not support the presence of clinically meaningful asthenia in space as we operationally defined it.[1]

To look for possible time effects, we divided our missions into fourths, calculated mean quarter scores for each subject on each of the eight POMS variables, and weighted each subject's mean quarter score by the number of observations contributing to the mean in the analysis. Using an analysis of variance for each variable, and applying the Benjamini and Hochberg procedure, none of the resulting *F* values was found to be significant. Thus, our POMS indicators of asthenia did not reveal any particular quarter of the missions to be more likely to show higher scores than any other quarter.

Table 2 shows the mean item scores for the Russian and American crew members taken separately, and there were no significant differences between these two groups after correcting for Type I errors using the Benjamini and Hochberg procedure. Thus, although asthenia has been reported primarily in the Russian space literature, American astronauts did not show any differences from Russian cosmonauts on any of our asthenia indicators.

**TABLE 2. Comparison of Shuttle/Mir Russian and American Crew Member Mean Scores on the "Asthenia" Items From the POMS[a]**

| POMS Item | Russians ($N$ = 8) | | Americans ($N$ = 5) | | $t$ | $p^b$ | Effect Size |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | | |
| On edge | 0.13 | 0.21 | 0.44 | 0.54 | −1.20 | .287 | −1.19 |
| Restless | 0.41 | 1.02 | 0.36 | 0.48 | 0.08 | .939 | 0.14 |
| Resentful | 0.04 | 0.08 | 0.16 | 0.23 | −1.18 | .295 | −0.71 |
| Annoyed | 0.10 | 0.25 | 0.60 | 0.55 | −2.26 | .045 | −1.85 |
| Forgetful | 0.10 | 0.15 | 0.28 | 0.35 | −1.24 | .240 | −0.84 |
| Unable to concentrate | 0.03 | 0.08 | 0.09 | 0.13 | −0.99 | .343 | −0.43 |
| Weary | 0.39 | 0.40 | 0.46 | 0.59 | −0.27 | .795 | −0.23 |
| Fatigued | 0.55 | 0.38 | 0.67 | 0.53 | −0.51 | .617 | −0.42 |

[a] Scale anchoring points: 0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, and 4 = extremely.
[b] None of the values are less than the Benjamini and Hochberg (33) adjusted significance threshold of $p$ = .006.

## DISCUSSION

The analysis of our data from astronauts and cosmonauts participating in a series of Shuttle/Mir space missions did not demonstrate the presence of asthenia when the crew members' on-orbit scores were compared with scores from a prototype of asthenia constructed by consensus assessments used in Russian space practice or with the preflight scores obtained during training. A number of issues might have accounted for this. First, the POMS could only evaluate parts of the syndrome because it primarily is a measure that assesses emotional states but not physiological status (eg, blood pressure, heart rate, and sleep characteristics) or somatic complaints that are part of the description of asthenia (eg, headaches, palpitations, excess perspiration, and sleep disturbances). Second, our operational definition of asthenia depended on eight POMS items, and perhaps these were not sensitive enough to identify aspects of the syndrome. Third, one of the items, Restless, behaved differently from the others: it produced the smallest effect size, it resulted in the only nonsignificant crew vs. expert difference, and it had the smallest interitem correlation with the other seven items. Thus, it seemed to be less robust than the other items as an operational indicator of asthenia. Finally, our procedure of averaging weekly crew member ratings across mission weeks captured neither systematic change nor differences in variability of ratings across time. If either of these phenomena had an impact on the manifestation of asthenia, this approach would be insensitive to those aspects. But it should be noted that even though our sample sizes were small, effects were detected and were quite large. Had we not found differences, the decreased power of our tests to detect effects would need to have been considered.

In absolute terms, our subjects rated the asthenia items in the "not at all" to "a little" range. This sug-

[1] We also used *t* tests to compare the mean scores from our mission control subjects with those of the Russian experts. Like the crew members, ground subjects scored significantly lower than the experts on seven POMS items (using an adjusted significance level threshold of $p$ = .044). The exception was the Restless item, where there was no difference (ground personnel mean = 0.79, expert mean = 1.00, $t$ = 0.40, $p$ = .706).

gests that they were not experiencing the intensity of the asthenia items to any appreciable extent. However, as we have reported elsewhere (28–31), the crew member subjects generally scored toward the positive end of the scales in our measures (including the POMS), and their responses were more adaptive than those from normative samples on Earth. This suggests that they reported or perceived their emotions and their interpersonal environment more optimistically than people in other groups on the ground. This might have reflected a tendency of the crew members to want to look good, perhaps because of their basic personalities or because of a conscious attempt to protect job security and avoid being grounded by minimizing any problems on board the Mir. For the asthenia items, these issues would be applicable to both Russian and American crew members, because they tended to score in a similar manner.

In contrast, the constructed prototype from the Russian experts yielded scores in a range that supported the validity of asthenia. Perhaps they were accurately describing a syndrome that can't be verified by subjective measures given to crew members. Alternatively, the experts may have unconsciously projected the way they might have felt in space instead of the way a highly selected and trained crew member with asthenia might have felt. It would be instructive to give the POMS to patients on Earth who are suffering from this syndrome as well as to nonpatients working in extreme environments (such as on submarines or in the Antarctic) because these might be more valid comparison groups.

Despite our negative findings, the importance of the concept of asthenia warrants further study. The syndrome should be better defined and characterized using stringent empirical methods. It should be compared with and differentiated from similar conditions, such as adjustment or depressive disorders, in both Russian and non-Russian populations. Physiological as well as psychological measures should be used, and these should be objective as well as subjective in format. Measures specific to asthenia need to be developed and validated in both clinical and astronaut populations. If further study identifies the presence of the asthenic syndrome in space, then preflight training programs and in-flight countermeasures to deal with its sequelae should be expanded to improve the well-being of astronauts and cosmonauts participating in future long-duration space missions.

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