AUTOGENIC FEEDBACK TRAINING APPLICATIONS FOR MAN IN SPACE

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ABSTRACT

Finding an effective treatment for the motion sickness-like symptoms that occur in space has become a high priority for NASA. This paper reviews the background research and procedures of an experiment designed to prevent space motion sickness in shuttle crewmembers. The preventive method used, Autogenic-Feedback Training (AFT) involves training subjects to control voluntarily several of their own physiological responses to environmental stressors. AFT has been used reliably to increase tolerance to motion sickness during ground based tests in over 300 men and women under a variety of conditions that induce motion sickness, and preliminary evidence from space suggests that AFT may be an effective treatment for space motion sickness as well. Other applications of AFT described include; (1) a potential treatment for post flight orthostatic intolerance, a serious biomedical problem resulting from long duration exposure to micro-g and (2) improving pilot performance during emergency flying conditions.

In space, the absence of gravity alone causes unique physiological stress. Significant biomedical changes such as body fluid redistribution, diminished musculoskeletal strength, changes in cardiac function and sensorimotor control have been reported.[23] The time course of development of these disorders and the severity of symptoms experienced by individuals varies widely. Space motion sickness is an example of maladaptation to microgravity which occurs early in the mission and can have profound effects on physical health and crew performance. Both the American and Russian space programs have suffered tragic and near tragic accidents, as well as a varied list of human errors and mistakes which have adversely impacted mission goals.[4,6] Continued probability of human exposure to microgravity for extended time periods provides a rationale for the study of the effects of stress, workload, and fatigue on human physiology and performance.[1,2]

Adaptation is defined as the "modification of an organism or its parts that makes it more fit for existence under the conditions of it's environment".[26] Perhaps individual differences in the ability to adapt to microgravity are related to differences in autonomic plasticity. Autonomic neural plasticity is a term which describes the capability of organisms to modify autonomic nervous system (ANS) function through learning.[21] As psychophysiologists, we study both physiological and behavioral indicators of human adaptation to the microgravity environment, with the goal of facilitating human adjustment to space as well as readaptation to Earth. The majority of our work has thus far, been dedicated to finding a method for preventing the symptoms of space motion sickness.

Motion sickness is a completely artificial disease which has plagued mankind since we first stepped onto a floating raft or climbed onto an animal's back. Characterized by symptoms of nausea, emesis, pallor, vertigo, sweating, and general malaise, motion sickness is not only debilitating, but in the case of military fighter pilots or astronauts in space, these symptoms can be lethal. Typically, motion sickness is treated with medications such as scopolamine or promethazine.[5,27] While these medications may be highly effective, they produce unwanted side-effects such as blurred vision, slower reaction time, decreased short-term memory, and impairment of decision making skill.[5,22,27] As such, American military pilots under the influence of such medications are not allowed to fly solo.[18,20]

Most research in this field has been devoted to the study of vestibular physiology, perceptual phenomena, or pharmacological intervention in man and in animals.[22] In contrast, the primary objective of our own research group has been to develop a method of training people to control their own motion sickness symptoms.[7-17,25] Our method of treatment is Autogenic-Feedback Training (AFT), which involves training physiological self-regulation.

Because our laboratory research[9,10] showed that certain ANS responses were correlated with, and were indeed predictors of (i.e., consistently preceded) reports of motion sickness distress, it was hypothesized that training subjects to control these responses might prevent or reduce symptoms. The observed individual differences in responding suggested that, to be effective, such training would have to be directed at the different responses for different people. In other words, training would have to be "tailored" for each individual.

AFT is actually a combined application of several physiological and perceptual training techniques, principal among these are Autogenic Therapy[24] and biofeedback. This combined therapies approach produces a methodology which is appreciably more effective than either of these two techniques when used alone.[3,7-17,25] Autogenic exercises provide the subject with a specific set of instructions and method of concentration which are likely to produce the desired response. For example, self-suggestions of warmth in the hands and feet are associated with measurable increases in peripheral vasodilatation.[24] Consequently, the time normally spent by the subject using a trial and error strategy is shortened and the initial probability of making a correct response is substantially increased. Biofeedback complements Autogenic Therapy by providing immediate sensory information to the subject about the magnitude and direction of a response. Operant conditioning procedures allow for more precise control of a response, as the "reward" (or feedback) can be presented only as the subject makes gradually larger response changes in the desired direction. As a result, the ultimate effectiveness of training is significantly increased.[13,17]

During a typical training session, subjects are instructed to control a pattern of (from 12 to 20 different) physiological responses and are given many different feedback displays, (visual and auditory) simultaneously. Multiparameter feedback requires additional training in attending to a complex set of feedback signals. Verbal instructions by the experimenter are often required to direct the subject's attention to specific feedback signals and to advise him of alternative strategies when an inappropriate response has occurred. Included in these alternative strategies are elements of systematic desensitization and progressive relaxation of muscle tension monitored at several sites.

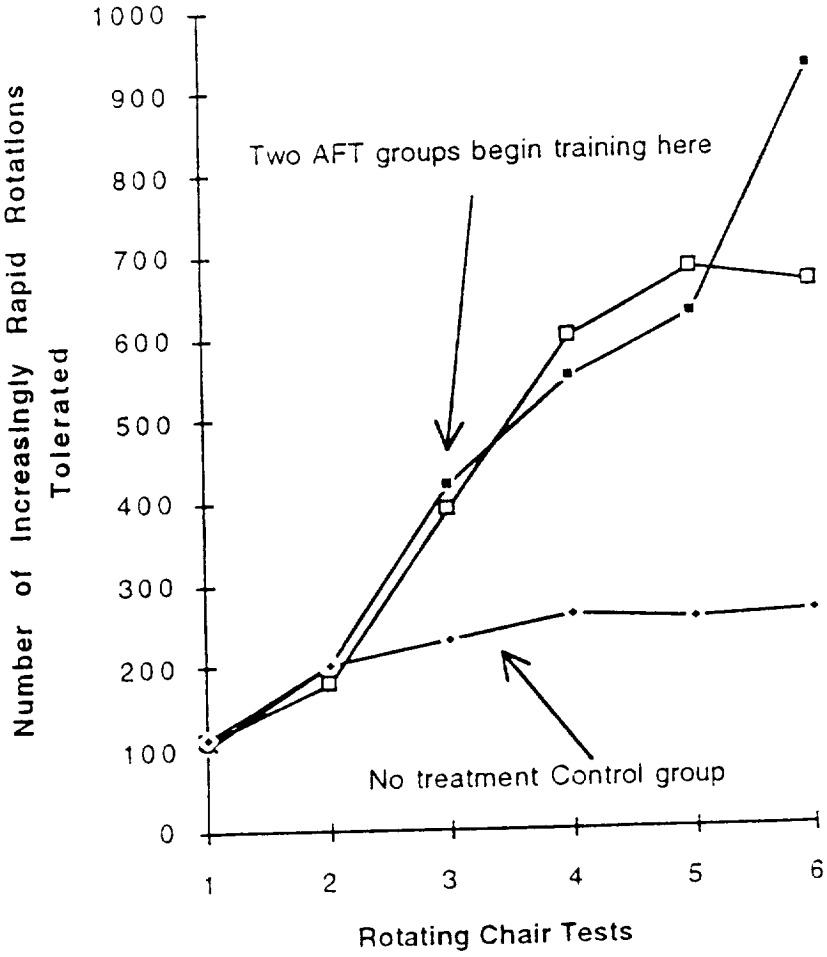
In preparation for tests of AFT in space, we conducted investigations on over 300 people. Each study was designed to test the effectiveness of AFT as a countermeasure for motion sickness and the feasibility of using AFT to prevent or reduce the severity of space motion sickness symptoms in aerospace crews.

The results of these studies showed: (1) increases in motion sickness tolerance were significantly greater following AFT than in control groups who received "no treatment" (i.e., habituation) or an alternative treatments (e.g., sham training); (2) training

could be effectively administered in a relatively short period of time (6 hrs total); (3) the ability to apply AFT to control symptoms was statistically the same for men and women; (4) the ability to control symptoms could be retained for as long as 3 years after training; (5) control of motion sickness symptoms readily transferred across a variety of nauseogenic conditions; (6) subjects who were highly susceptible to motion sickness could learn to suppress their symptoms at the same rate as subjects who were initially more resistant to nauseogenic stimuli; and (7) after extensive examination of potential intervening variables under controlled experimental conditions, it was concluded that the primary component of the treatment effect in each of these studies could most probably be attributed to learned control of physiological response levels and lability.

Figure 1 illustrates the results of one of these studies.[17] Three groups of subjects (N=12) matched for initial susceptibility to motion sickness tolerance were given six rotating chair motion sickness inducing tests separated by one week intervals. The two groups of AFT subjects were given 2 hrs of training before the third, fourth and fifth rotating chair tests. The control group was given no training or alternative treatment.

Figure 1. AFT subjects improve tolerance to rotating chair motion sickness tests



The validation of the AFT treatment effect is substantiated by the observation that subjects who increased their tolerance to motion sickness inducing tests consistently showed a statistically significant reduction in the magnitude of changes in autonomic responses after training than before, and that control of symptoms during the rotating chair tests was related to the degree of autonomic control demonstrated during AFT sessions. AFT has advantages over other self-regulation training methods for this particular application because it enables training individuals to regulate the levels of multiple physiological responses simultaneously, thus enabling a more system-wide reduction in reactivity to stressors responses.

AFT, as described in this paper, was developed for use in the NASA space program as an alternative to traditional pharmacological treatment for space motion sickness, and has been tested successfully aboard two shuttle missions.[12,13] Recently, our own research group completed a preliminary study[14] which was designed to examine the feasibility of training shuttle crewmembers to increase their blood pressure during orthostatic challenge (i.e., a tilt table), as a potential countermeasure for post-flight orthostatic intolerance (i.e., low blood pressure). The results showed that with AFT subjects could increase their blood pressure and mean arterial pressure (MAP) significantly from baseline levels while supine and during 45° head-up tilt. Blood pressure and MAP were significantly higher during tilt after training than before. The magnitude of systolic and diastolic pressure increases for all subjects ranged maximally between 20 and 50 mmHg.

A number of 'space medicine spin-off' applications for AFT in finding solutions to Earth-based problems have been and continue to be explored. Included among these are tests of AFT for training cancer patients to suppress the nausea associated with radiation or chemotherapy,[15] improvements in the effectiveness of the treatment of essential orthostatic intolerance (e.g., as in paralyzed patients); and the successful treatment of military pilots suffering from intractable airsickness, for whom all other forms of treatment had failed.[16,18,20] Most recently, a study demonstrated that AFT significantly improves pilot performance during emergency flying conditions in a number of areas including: crew coordination and communication, planning and situational awareness, stress management, and aircraft handling.[19] It was concluded that the pilot performance improvements observed were due to learned self-regulation of autonomic responses to environmental stressors. These findings may be instrumental in reducing stress-related performance decrements associated with 'human error' fatal aircraft accidents. In the future, we hope to apply the lessons learned about multi-crew aircraft performance to passengers and crew in spacecraft.

References:

1. Benke, T., Koserenko, O., Gerstenbrand, F. (1993). Cogimir: A Study of Cognitive Functions in Microgravity. Space Technology, 13, (2); 181-183.
2. Benke, T., Koserenko, O.,Watson, N.V., and Gerstenbrand, F.(1993). Space and cognition: The Measurement of Behavioral Functions During a 6-Day Space Mission. Aviat. Space & Environ. Med., 64, 376-379.
3. Blizzard, D., Cowings, P. and Miller, N.E. (1975). Visceral responses to opposite types of Autogenic Training imagery. Biological Psychology, 3, 49-55. And in (Barber, T.X. et al. Eds.) Biofeedback and Self- Control, Chicago: Aldine Publishing Co. 1976.
4. Bluth, B.J. The psychology and safety of weightlessness. Paper presented at the 15th Symposium on Space Rescue and Safety, Paris, France, 1982.
5. Brandt, T. (1974, November). Drug effectiveness on experimental optokinetic and vestibular motion sickness. Aerospace Medicine, pp. 1291-1297.

6. Connors, M., Harrison, A., & Akins, F.(1985), Living Aloft: Human Requirements for Extended Spaceflight, NASA SP-483; p 107 - 143.
7. Cowings, PS, Billingham, J, Toscano, WB. Learned control of multiple autonomic responses to compensate for the debilitating effects of motion sickness. Therapy Psychosom Med. 1977;4:318-23. And in: W. Luther & F. Antonelli, Eds.) Autogenic Methods: Application and Perspectives. Rome: Luigi Pozzi S.P.A.; 1977. And in: (Barber, T.X., et al Eds.) Biofeedback and Self-Control 1977/78. Chicago: Aldine Publishing Co.;1978:482-87.
8. Cowings, P.S. and Toscano, W.B.. Psychosomatic health: Simultaneous control of multiple autonomic responses by humans- a training method. Therapy in Psychosom Med, 1977;4:184-190. And in (W. Luthe and F. Antonelli, Eds.) Autogenic Methods: Application and Perspective. Rome: Luigi Pozzi S.P.A., 1977.
9. Cowings, PS, Naifeh, KH, Toscano, WB. The stability of individual patterns of autonomic responses to motion sickness stimulation. Avia. Space Environ Med. 1990;61:(5),399-405.
10. Cowings, P.S., Suter, S., Toscano, W.B., Kamiya, J. and Naifeh, K. (1986). General autonomic components of motion sickness. Psychophys, 1986;23:(5), 542-51.
11. Cowings, P. S. and Toscano, W. B. (1982). The relationship of motion sickness susceptibility to learned autonomic control for symptom suppression. Avia, Space Environ Med 1982;.53,:(6), 570-5.
12. Cowings, P. S., Toscano, W. B., Kamiya, J., Miller, N. E. and Sharp, J. C. . Final Report. Spacelab-3 Flight Experiment #3AFT23: Autogenic-Feedback Training As A Preventive Method for Space Adaptation Syndrome.. NASA Technical Memorandum No. TM89412. National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California. 1988.
13. Cowings, P.S. and Toscano, W.B. (1993) Autogenic-Feedback Training (AFT) as a Preventive Method for Space Motion Sickness: Background and Experimental Design. National Aeronautics and Space Administration: NASA Technical Memorandum 108780.
14. Cowings, P.S., Toscano, W.B., Kamiya, J., Miller, N.E., Pickering, T. and Shapiro, D. (1993) Autogenic-Feedback Training: A Potential Treatment for Post-Flight Orthostatic Intolerance in Aerospace Crews. NASA Technical Memorandum No. 108785. September, 1993.
15. Cowings, P.S. (1993). Can Autogenic-Feedback Training Reduce Nausea Associated with Therapy for Cancer? NASA Ames Research Center, Director's Discretionary Fund Research. In progress.
16. Cowings, P.S., Toscano, W.B., Miller, N.E. and Reynoso,S. (1994). Autogenic Feedback Training As a Treatment for Air-Sickness in High Performance Military Aircraft: Two Case Studies. NASA Ames Research Center. Technical Memorandum NO. 108810, March 1994.
17. Cowings, PS. Autogenic-Feedback Training: A Preventive Method for Motion and Space Sickness. In: Crampton G, Ed. Motion and Space Sickness. Boca Raton Florida: CRC Press, 1990:354-72.
18. Jones, D.R., Levy, R.A., Gardner, L., et al. (1985). Self-control of psychophysiologic response to motion stress: Using biofeedback to treat airsickness, Aviation, Space, And Environmental Medicine, 56, December, 1152-1157.
19. Kellar, M.A, Folen, R.A., Cowings, PS, Toscano, WB, and Hisert, GL. (1993) Autogenic Feedback Training Improves Pilot Performance During Emergency Flying Conditions. National Aeronautics and Space Administration: NASA Technical Memorandum 104005.
20. Levy, R.A., Jones, D.R., and Carlson, F.H. . Biofeedback rehabilitation of airsick aircrew. Aviat Space Environ Med. 1981;52, 118-21

21. Pavlov, I.P. (1951) The Complete Works of Pavlov. Nauka: Moscow.
22. Reason, J.T and Brand, J.J, (1975). Motion Sickness. New York: Academic Press.
23. Sandler, H. and Vernikos, J. (eds.). (1986). Inactivity: Physiological Effects, Orlando: Academic Press.
24. Schultz J.H. and Luthe, W. (1969). Autogenic Therapy, Vol. I: Autogenic Methods. New York: Grune & Stratton.
25. Toscano, W.B. and Cowings, P.S Reducing motion sickness: Autogenic- Feedback Training compared to an alternative cognitive task. Avia, Space Environ Med. 1982;53:(5), 449-53.
26. Webster's New Collegiate Dictionary (1979)
27. Wood, C.D., Manno, J.E., Manno, B.R., et al. (1985). Evaluation of antimotion sickness drug side effects on performance, Aviation, Space, and Environmental Medicine, 56, April, 310-316.

Biographical Sketch

Dr. Cowings served for 21 years as director of psychophysiological research at NASA's Ames Research Center. She is the principal investigator of a series of Shuttle experiments designed to study and facilitate human adaptation to microgravity. She is married to her coinvestigator and they have a 7-year old son.