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Cognitive and Psychomotor Performance in Extreme and Unusual Environment

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ABSTRACT

The purpose of the study is to examine the effect of long-term residence on cognitive function and to determine the impact of winter on psychomotor performance of personnel who stayed for long duration in extreme and unusual environment of Antarctica. Twenty-four volunteers from winter-over team of Indian Antarctic Expedition served as participants. For comparison of winter-over and summer personnel on perceptual function, twenty-one subjects from summer team volunteered. The results revealed a positive effect in tasks of recognition memory, vigilance and learning, and neutral effect in short-term memory for digit recall over prolonged duration of residence. Spatial discrimination and Müller-Lyer illusion showed no substantial difference over winter in Antarctica. However, the accuracy of spatial discrimination was low for winter-over personnel when compared to summer personnel who stayed for a short period during summer in Antarctica. On psychomotor performance, the hand steadiness and two-hand coordination showed significant increase in performance while, performance in finger dexterity was stable over winter. Overall, this study highlights a positive effect on cognitive and psychomotor performance during long-term residence in Antarctica.

Keywords: Cognitive Function, Perceptual Function, Psychomotor, Antarctica, Extreme Environment, Duration, Long-term Residence.

INTRODUCTION

Extreme environments are characterized as those situations which place a high demand on the physiological, affective, cognitive, and/or social processing resources of the individual. With the development of technology, human capabilities have expanded and made it possible for human beings to reside in extreme and unusual places that we could neither reach nor have survived in the past. Consequently, an increased number of people are travelling or residing for scientific or recreational purposes in isolated and extreme environments such as space, planets, circumpolar regions, nuclear submarines, undersea research laboratories, super-tankers, etc. The best analog is the scientific research station operating year-round in Antarctica.

Antarctica is a place of great beauty, but it is also a place of great extremes. As the coldest, largest, driest, and windiest of the Earth's continents, it is no wonder that there are no permanent inhabitants (Palinkas, 1992). The major stressors in the unusual Antarctic environment appear to be isolation, the sameness of the environment, and the lack of customary sources of satisfaction (Mullin, 1960; Strange and Youngman, 1971).

Several researchers have suggested that prolonged exposure to extreme and unusual conditions might cause some loss of cognitive ability (e.g., Mullin, 1960; Angus, Pearce, Buguet, and Olsen, 1979; Palinkas, 1992). It has been stated that cold exposure, prolonged isolation, and unusual conditions may adversely affect vigilance, concentration, memory (recognition and recall), and reasoning ability (see Palinkas, 2001; Hoffman, 2001). Using a series of "mental paper folding" tasks of increasing difficulty, White, Taylor, and McCormick (1983) found deterioration in performance after wintering as well, a comparison with a control group confirmed this performance deterioration for the wintering-over group. However, some studies recorded no reduction or substantial decrements in cognitive performance (Le Scanff, Larue, and Rosnet, 1997; Marrao, Tikuisis, Keefe, Gil, and Giesbrecht, 2005) and few investigators observed even improved cognitive performance in extreme environment (Palinkas et al., 2005; Mäkinen et al., 2006). For instance, Defayolle, Boutelier, Bachelard, Rivolier, and Taylor (1985) observed improvement in Antarctic expeditioners when tested for immediate memory, visual discrimination tasks, and reaction time.

Cognitive performance seems to show change in reduced stimulus condition, which is natural in polar environment. A few investigators reported improvement in memory and other cognitive functions under sensory deprived conditions (for example, Vernon and Hoffman, 1956; Grissom, Suedfeld, and Vernon, 1962; Suedfeld, 1969; Defayolle et al., 1985; Suedfeld, Ramirez, Remick, and Fleming, 1987). Some studies on isolated and confined group experiments as well as on reduced stimulation environment demonstrated no deterioration in cognitive performance over a period (Rasmussen, 1973; Brady and Emurian, 1978; Suedfeld, 1980; Manzey, Lorenz, and Poljakov, 1998). A few researchers suggested that performance deterioration in reduced stimulation environment might be due to loss of motivation than of cognition or to slower pace of life in a relatively unstimulating environment (Suedfeld, 1969; Rasmussen, 1973; Taylor, 1987).

Literatures on the extreme and unusual environment furnish a great deal of knowledge on the cognitive performance. However, most of the studies have primarily focused on the cognitive processes such as memory, attention, vigilance, etc. The perceptual processes and motor skills were relatively less examined, though such psychomotor abilities gain a greater significance in the context of unusual environment characterized by sensory and perceptual deprivation and the sameness of the environment (Barabasz, 1980; Mullin, 1960; Strange and Youngman, 1971).

Some of the extreme and unusual environments clearly do cause major shifts in perceptual and motor skills. Smith (1966) found that Antarctic personnel on field expeditions consistently overestimated sizes of objects and under-estimated distances from objects. In traditional environment, attention is, by default, deployed to the foreground than the background (see, Mazza, Turatto, and Umilta, 2005). But in the unusual and extreme environment like Antarctica, the foreground-background segments are relatively fuzzy. Also normal spatial cues are removed or changed, which produce unusual viewing condition and visual distortions (Suedfeld, 1987). It was stated, "the frequent blizzards and lack of observable landmarks may interfere with visual perception" (Rothblum, 1990, p. 265). Further, Smith (1966) and Ross (1975) reported that unusual viewing condition distort the perceived size and distance of objects. However, studies of visual process in sensory or perceptual deprivation and confinement have yielded a differential pattern of results (Benke, Koserenko, Watson, and Gerstenbrand, 1993; Doane, Mahatoo, Heron, and Scott, 1959; Suzuki, Fujii, and Onizawa, 1965; Zubek, Pushkar, Sansom, and Gowing, 1961).

Segall, Campbell, and Herskovits (1966) found that people who lived in a 'circular hut' are less affected by the Müller-Lyer illusion whereas those who are more subject to the illusion lived in a 'carpentered world' of rectangles and parallel lines. Similarly, Segall et al., (1966) reported that people who lived in very open rural environments are more inclined to the horizontal-vertical illusion. Such studies lead to the assumption of illusory-effects on Antarctic sojourners who move from habituated milieu to the unusual environment or the icy-wilderness of Antarctica.

It is known that cold exposure primarily affects performance in dexterity or motor skills. These impairments are largely due to stiffening of the muscles, joint and possible synovial joint fluids, resulting in a mechanical 'locking up' of the biomechanical capabilities of the hands. The work of Gaydos (1958) and Bensel Lockhart (1974) concluded that manual dexterity tasks are affected whenever the hands are cooled to a critical peripheral skin temperature of 55° F. Loss of dexterity in the cold is also accompanied by reduction of tactile sensitivity, resulting in diminished feedback as to what the hands are doing. Manzey et al. (1995) reported that psychomotor processes and higher attentional functions are particularly prone to disturbance effects in extreme environment. Teichner and Kobrick (1955) observed that visual-motor performance was markedly and immediately impaired in the cold and recovered gradually, but to a lower limit than it attains under optimal temperature conditions. Lockhart (1966) suggested that cooling the body while maintaining normal hand skin temperature does not affect performance of tasks involving only wrist-finger speed and dexterity. Conversely, it was found that decrements in psychomotor performance resulting from cold exposure cannot always be alleviated by maintaining normal hand skin temperature (Lockhart, 1968). In general, only extreme levels of body cooling have been shown to affect performance.

It is obvious from the available studies that extreme and unusual environment influences cognitive and perceptual processes. It is evident that a widespread of studies conducted in extreme and unusual environment has focused primarily on the effect of season, cold exposure, isolation, and sensory deprivation in examining cognitive performance. However, only a few studies have given specific emphasis to the impact of prolonged duration in unusual or extreme environment. Further, it was clear that there is little empirical evidence on perceptual processes and motor skills in the extreme and unusual environment. Anecdotal records and personal experiences of Antarctic personnel have claimed perceptual deterioration and impairments in manual dexterity, but systematic study on psychomotor performance in extreme environment is scanty.

Thus, with the above background the investigators formulated the following objectives:

1. To investigate cognitive performance - task acquisition, delayed recognition, attention and concentration, digit symbol substitution, and vigilance over a long-duration of residence in isolated and extreme environment.

2. To examine the effect of winter in perceptual function - spatial discrimination and Müller-Lyer illusion, and to compare winter-over and summer personnel in perceptual function.
3. To determine how prolonged exposure to cold in extreme environment affects psychomotor performance – hand steadiness, finger dexterity, and two-hand coordination.

METHOD

Participants: Twenty-three men and one woman of the winter session team that stayed for duration of fourteen months at 'Maitri' – the Indian Research Base in Antarctica (70^{0}45'S, 11^{0}44'E) volunteered to participate in this study. Among twenty-four participants, six men had already served in Antarctica in different expedition team. For the remaining members it was the first winter-over experience in Antarctica. The mean age of winter session team participants was 39.13 yrs (SD=8.4 yrs). Twelve volunteers had professional background and the remaining volunteers were technical support personnel. The summer session team included 21 volunteers, who had no prior experience of winter and had completed one-month duration of stay in Antarctica. The mean age of summer session team was 42.5 yrs (SD=9.3 yrs). Each subject was medically and psychologically screened and qualified for winter-over duty. The screening and selection were done by the National Centre for Antarctic and Ocean Research, Government of India. Informed consent was obtained from each participant after the study objectives and data collection procedures had been thoroughly explained. Excluding participants, the second author of this study participated as a psychologist in the Indian Scientific Antarctica Expedition.

TEST MATERIALS AND APPARATUSES

This section covers a brief description of the psychological tests and apparatuses and also the method of administration as directed in the manuals of psychological materials. Cognitive function was assessed using cognitive tasks that measure memory, vigilance, and learning ability.

i. *Task Acquisition:* Trahan and Larrabee's (1999) task acquisition test was used to measure the recognition memory. The task acquisition test items (labelled 1-112 in the card deck) are based on 70 different complex ambiguous designs. Of these 70 designs, 7 are recurring designs and appear seven times each during the administration of the test. In addition, there are 6 distraction designs for each of the seven categories of stimuli. Finally, there are 21 complex ambiguous designs selected from design categories unrelated to the recurring designs. This test required the subject to discriminate 'new' versus 'old' stimuli from among a set of 112 complex designs, which were presented in a rapid sequence. The exposure time limit for each item was less than 3 seconds.

ii. *Delayed Recognition:* Trahan and Larrabee's (1999) delayed recognition task was used primarily to measure retrieval deficits. The delayed recognition task stimuli consists of seven cards, each of which presents one of the seven recurring designs along with the six distraction designs from within the same stimulus category. This task required the subject to recognize the old stimuli from sets of perceptually similar stimuli. This test was administered 30 minutes after the completion of the Acquisition task and the subject was not informed about this delay procedure. The subject was required to give response within 15 seconds. The reliability and validity for task acquisition and delayed recognition tests were established by Trahan and Larrabee (1999) and these tests were used because they distinguished potential learning deficits from retention problems.

iii. *Attention and Concentration:* The test of Attention and Concentration in Post Graduate Institute Memory Scale (Pershad and Wig, 1994) is a measure of short term memory for digit. This test required the subject to repeat forward or backward a series of orally presented digits increasing one digit at a time. The Post Graduate Institute Memory Scale (PGIMS) was chosen because it was not unduly dependent on intelligence and was also widely accepted standardized tool for Indian population.

iv. *Digit Symbol Substitution:* The Digit Symbol of Wechsler Adult Intelligent Scale – Revised (WAIS-R) is a broadly used test that involves substituting code for numbers. The duration of the test was 90 seconds. Although perceptual-motor speed is the prime determinant of digit symbol performance, this study assessed learning and memory from evaluating the accuracy of responses.

v. *Vigilance:* P-Detection test was used to measure vigilance. The test required the subject to find the alphabet "P" among the series of "R" that is seen in the test paper. The time limit for the test was 90 seconds.

vi. The psychomotor performance was assessed using the following apparatuses.

vii. *Spatial discrimination:* The spatial discrimination was measured by Lehman-type space-discrimination meter (2005). The apparatus was presented horizontally to subject and was instructed to divide by eye a space of 30 mm between the two indicating lines into two equal parts with the use of the parallel and movable line. Four trials with moveable line closer to centre and four trials with moveable line away from centre were given. In each trial, the error in measurement was read on the millimetre scale at the reverse side of the meter. The mean error was calculated in millimeter from eight trials.

viii. *Müller-Lyer illusion:* The illusion-effect for a Müller-Lyer figure was measured by the Müller-Lyer illusion apparatus (2005). This apparatus had a Müller-Lyer figure with arrangement for varying the length between the feather-head points. The distance between the arrow-head points was constant (50 mm). Presenting the apparatus horizontally, the subject was given the instructions for the test (Mann, 1962). In the first half of the observations, subject was asked to keep the feather-head points equal to the given standard figure (constant arrow-head points) by pulling inwards the strip with feather-head point. In the other half of observations, the same series was repeated but by pulling the feather head strip outwards from the standard figure. Eight set of observations were made in which four sets were with movement inwards and other four sets with movement outwards. Two minutes of rest was given after the first half of the observations. For all set of observations, the under-estimation of the standard arrow-head figure, as compared with the variable feather-head, called the 'constant error' was calculated in millimeter.

ix. *Two-hand coordination:* This test measures the ability to operate motor activities. The apparatus consists of an aluminum plate upon which are secured a slightly elevated triangle and a corresponding quadrilateral, made of hard rubber. The strips forming these figures are of uniform breadth. Subject was given a stylus one for right hand and a similar one for left hand. Either stylus, upon coming in contact with the aluminum plate, registers a sound with an electric buzzer. The data was recorded in terms of the number of times the subject touched the side of the hole (error). At the start of the signal, subject began to trace the figures, both hands going counter clock-wise. The subject was instructed to start and to stop both hands simultaneously. The right hand should describe its figure, the quadrilateral, in four counts, while the left hand completes its round in three. Ten successive trials were given and no time restriction was followed for any of the trial. The total error was counted and recorded at the end of each trial.

x. *Hand Steadiness:* This test measures the ability to operate various controls of sophisticated equipments. Subject was instructed to hold the stylus with his hand firmly and insert the styles slowly and steadily into the test hole with the biggest diameter. Subject asked to keep the styles for 30 seconds in each hole. Error was counted when the styles touched the side of the hole. In this way, the test required subject to insert the stylus one by one in all the nine holes. The holes of the test are arranged in order of difficulty, that is, the diameter of each hole decreases progressively. Totally three trails were given and the total error was counted and recorded for each trial.

xi. *Finger Dexterity:* The subject was seated comfortably at a table about 30 inches in height. The board was placed in front of the subject about a foot from the edge of the table. The tray was placed on the right side of the subject if he was right-handed. The board was placed at an angel of 90° from the subject's preferred working hand. The board had 100 holes that have room for 1 pin in each of them. At a time, the subject picked up 1 pin and filled in each of the holes as fast as he/she can. Using the preferred hand, subject started in the farthest corner of the board and was working from left to right side if he was right handed and vice versa. There were extra pins in the tray so that if subject dropped one or two on the floor, he/she will still have enough pins left. A few demonstrative trials were shown to subject by the experimenter. Four trials were given to subject, motivating the subject to work even much faster at the end of each trial. The time taken in each trial was recorded and tabulated.

PROCEDURE

For examining the effects of prolonged duration of residence on cognitive performance, within-subject design was employed and participants were assessed at three different phases, that is, at the beginning (second month), the middle (seventh month) and the final (twelfth month) phases of long-term residence in Antarctica. The beginning and the final phases were the summer season, characterized by prolonged light and outdoor activities. The middle phase was the winter season characterized by prolonged darkness and reduced mobility.

At each phase, time taken for test administration was approximately 45 min. The tests were taken at the convenient time of the volunteer. Each session began with task acquisition test followed by attention and concentration, vigilance, and digit symbol tests. Delayed recognition test was administered following 30 min of interval from task acquisition test, as instructed in the test manual.

The psychomotor tests - spatial discrimination, Müller-Lyer illusion, hand steadiness, finger dexterity, and two-hand coordination were measured at the beginning (March) and at the end of winter season (October) on volunteers of winter session team. (Appendix 'A'). In the six months duration of winter, first and last two months had long nights and short days, whereas the middle two months had prolonged darkness, and twilight on some days. The lowest temperature recorded in winter at the Indian research base was –38°C and the average temperature in winter was –24°C. The Indian station was equipped with basic facilities to protect from cold and a temperature ranging from +15°C to +22°C was regularly maintained inside the station. Owing to prolonged darkness and unpredictable weather conditions during winter, all personnel spent the maximum hours of the day inside the base station. The summer session personnel resided for a very short duration during summer in Antarctica (December – February). The present study regarded the summer session as the Antarctic-control group for comparing the effect of winter session. The spatial discrimination ability and the Müller-Lyer illusion effect were studied on volunteers of summer session, who had completed one-month duration in summer.

RESULTS

The mean score and standard deviation of accurate responses on task acquisition, delayed recognition, attention and concentration, and digit symbol tests at the beginning, the middle, and the final phases of long-duration residence are presented in Table 1. A repeated measures MANOVA was conducted to assess if there was significant difference over extended duration in the accuracy of response on the five outcome measures. A Significant multivariate effect was found for the main effect of phase, Wilk's $\Lambda = .241$, $F(8, 15) = 5.90$, $p < .005$, multivariate $\eta^2 = .75$. The follow up repeated measures ANOVAs indicated that the main effect of phase was significantly different for task acquisition, delayed recognition, digit symbol tasks, and vigilance, $F(2,44) = 4.28$, $p < .05$, $F(2,44) = 10.60$, $p < .01$, $F(2, 44) = 5.32$, $p < .01$, and $F(2, 44) = 23.92$, $p < .01$ respectively.

Table 1—Mean and standard deviation values for cognitive tasks at beginning, middle, and final phases of long-duration residence in Antarctica

Cognitive tasks	Beginning Phase		Middle Phase		Final Phase	
	Mean	SD	Mean	SD	Mean	SD
Task Acquisition *	70.87	6.42	73.26	7.97	74.91	8.61
Delayed Recognition *	2.74	1.86	4.09	1.64	3.91	1.67
Attention and Concentration	6.39	1.27	6.48	1.62	6.96	1.74
Digit Symbol *	52.61	9.47	54.57	8.49	57.39	9.49
Vigilance *	9.05	2.98	13.75	4.42	14.6	3.67

* Significance level, $p < .05$

Contrasts revealed a significant linear trend for task acquisition, $F(1, 22) = 6.21$, $p < .05$, $r = .22$, and digit symbol, $F(1, 22) = 11.88$, $p < .005$, $r = .35$. For delayed recognition task, there was a significant linear and quadratic trend, $F(1, 22) = 9.77$, $p = .005$, $r = .30$ and $F(1, 22) = 12.50$, $p < .005$, $r = .36$ respectively. Besides, Bonferroni post-hoc test indicated that delayed recognition ($p = .01$) and digit symbol ($p < .01$) tasks significantly differed from the beginning phase to the final phase. Also, a significant difference was observed between the beginning and the middle phases for delayed recognition tasks only ($p < .01$). The pairwise comparison for vigilance showed significant difference in beginning and middle phases, between beginning and final phases. Likewise, the polynomial contrasts revealed significant linear trend in performance on vigilance from beginning to final phases, $F (1, 22) = 42.88, p < .01$. Examination of the means suggests that there was a proportionate increase in the accuracy of responses in task acquisition, delayed recognition, digit symbol, and vigilance tasks from beginning to final phases of prolonged duration of residence.

The data of spatial discrimination was analyzed by paired samples test whereas, Müller-Lyer illusion was analyzed by Wilcoxon signed ranks test. For winter session, spatial discrimination at pre-winter ($M = .39$, $SE = .03$) and at post-winter ($M = .38$, $SE = .03$), did not show significant difference, $t (23) = .229$, $p > .05$, $r = .04$. Likewise, pre-winter ($Mdn = .20$) and post-winter ($Mdn = .25$) constant errors of Müller-Lyer illusion did not differ significantly, $Z = 1.02$, $p > .05$, $r = .14$.

As part of this study, the post-winter data of the winter session was compared with the data of the summer session, which was regarded as the Antarctic-control group. Spatial discrimination analyzed by Independent samples test, revealed a greater difference between the winter session ($M = .38$, $SE = .03$) and the summer session ($M = .25$, $SE = .02$). The difference was significant, $t (43) = 2.82$, $p < .01$, and it represented a medium sized effect, $r = .39$. Müller-Lyer illusion, analyzed by Mann-Whitney's U-test, showed that the winter session ($Mdn = .25$) and the summer session ($Mdn =. 20$) did not differ significantly, $U = 236$, $Z = .36$, $p > .05$ (see Figure 1).

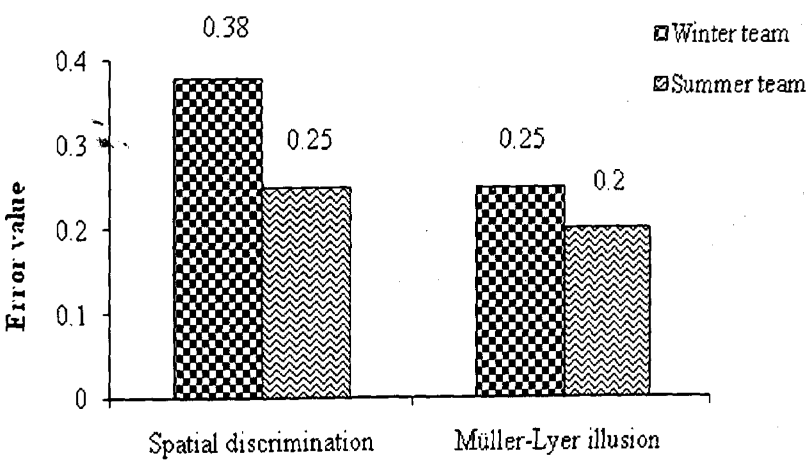

Fig. 1: Spatial discrimination (mean error) and Müller-Lyer illusion (constant error) between winter and summer sessions

With respect to psychomotor performance, the pre-and-post winter data on hand steadiness, two-hand coordination, and finger dexterity appeared to be non-normal ($p = .05$), and hence, they were analyzed by Wilcoxon signed ranks test. The mean error (error count) of hand steadiness at pre-winter (Mdn = 9.02) and at post-winter (Mdn = 7.62) showed significant difference, $Z = -2.20$, $p < .05$. Likewise, the mean error (error count) of two-hand coordination at pre-winter (Mdn = .70) and at post-winter (Mdn = .19) showed significant difference, $Z = -2.71$, $p < .01$. However, pre-winter (Mdn = 175) and post-winter (Mdn = 174) mean error (in seconds) of finger dexterity did not differ significantly, $Z = -1.24$, $p > .05$.

In summary, findings of this study indicated differential pattern effects on cognitive performance among Antarctic personnel over a long duration of residence. The tasks that measured mental speed, vigilance, and visual recognition memory showed improvement, while the task assessing short-term memory for digit was found stable over a long-duration of residence. Another finding indicated that the accuracy of spatial discrimination and the magnitude of Müller-Lyer illusion were stable in the winter session. Nevertheless, when compared with the Antarctic-control group, that is the summer session, the winter session demonstrated a significant difference in the accuracy of spatial discrimination. The magnitude of Müller-Lyer illusion did not show marked difference between the summer and the winter sessions. The performance on psychomotor tasks of hand steadiness and two-hand coordination showed improvement after winter season, while the performance in finger dexterity was found stable in the winter session members.

DISCUSSION

This study attempted to examine cognitive and psychomotor performance over a long-duration in extreme and unusual environment. Findings indicated a positive as well as neutral effect on cognitive performance among long-term residents. The tasks measuring mental speed, vigilance, and visual recognition memory showed an improvement on performance over a long-duration. This finding is consistent with some of the previous reports that observed an increase on cognitive performance (for example, Defayolle et al., 1985; Mäkinen et al., 2006; Suedfeld et al., 1987). On task measuring short-term memory, performance was stable from the beginning to the final phases of long-duration of residence. This finding is in line with the work of Suedfeld (1969) who upon reviewing some consistent findings concluded that no significant decrement occur on digit span as a result of any of sensory deprivation. Further, quite a few studies that have recoded no reduction on cognitive performance over time are in support of the present finding (for instance, Brady and Emurian, 1978; Marrao et al., 2005; Suedfeld, 1980; Taylor, 1991).

There are several studies that have noted cognitive impairments on long-term residents in polar environment (Mullin, 1960; Palinkas, 1992; Strange and Youngman, 1971). Such incongruence in findings could well be attributed to sample characteristics, logistic applied, simplicity and nature of the task, varied environmental conditions under which studies have been conducted, etc. Hence, findings of the present study need certain explanations.

The enhanced performance on mental speed, vigilance, and visual recognition memory may be attributed to decreased environmental distractions in polar environment (Zuckerman, 1969). It is believed that mental speed and visual recognition tasks may have improved, as there were little physical interferences to sensory input for distraction factor. On the other hand, the stable performance on short-term memory for digit may be ascribed to individual's limited ability to store and retrieve numerals in a given spell of short duration.

Other possible causes that facilitated or unaffected cognitive performance may include sample characteristics, rigorous medical and psychological screening that participant had gone through before the expedition. The medical status ensured that these participants better adapt with the polar environment and the psychological status confirmed that the participants were intellectually efficient and had high degree of motivation and tolerance. These factors could have contributed to stable as well as improved cognitive performance over a long duration of residence in polar environment. However, the exact mechanism for the differential effects on mental speed, visual recognition memory and short-term memory remains to be further elucidated.

The fact that some cognitive tasks were faster as well as more accurate with the extended duration of residence in extreme environment could support the arousal hypothesis (Payne, 1959; Provins et al., 1973; Ellis et al., 1985, Enander, 1987; Van Orden et al., 1990). It is possible that under the moderate cold exposure (as a result of sophisticated thermal clothing and well-equipped polar station), and with the limited amount of stimulus under sensory deprivation, arousal was increased to a level, which improved performance. Also, it can be said that as a result of awareness and experience of the hardships in extreme environment, the winter-over personnel habituated to exercise greater attention on tasks at hand. The other possible explanation for the improved cognitive performance could be that the tasks employed in the study were simple and do not require that-much attention as compared to the complex tasks.

Although not studied in detail in the present study, motivation may have significantly affected cognitive performance. Highly motivated individuals tend to be more aroused and less susceptible to distraction. It is possible that psychological screening of personnel at the onset of Antarctic expedition may have resulted in highly motivated and skilled participants. However, the association between motivation and cognitive performance on long duration of residence in extreme conditions warrants further studies.

The stable performance on spatial discrimination and Müller-Lyer illusion in the winter session is consistent with some of the studies that noted no reduction on perceptual processes as a result of deprivation or confinement in restricted environmental stimulation (Benke et al., 1993; Zubek et al., 1961). At the same time, this study demonstrated that winter session differed significantly from the summer session in the accuracy of spatial discrimination. This finding seems to confirm the reports that stated perceptual distortions owing to frequent blizzards and unfamiliar environment (see Ross, 1975; Rothblum, 1990; Smith, 1966; Suedfled, 1987).

It is interesting to know that observation in the winter session, and the study between the winter and the summer sessions are negating each other. A possible reason could be adjustment and habituation of winter-over personnel to unusual environment over a long duration of residence. It is noteworthy to mention that the study in the winter session began when participants had almost completed three months of duration in Antarctica. Perhaps, changes in perceptual processes might have occurred in the winter session in initial phases of adjustment to novel environment. And the altered state of perceptual processes might have continued during the onset of winter and for the rest of duration in the winter session. Hence, there was non-significant difference on spatial discrimination and Müller-Lyer illusion before-and-after winter. The summer session (Antarctic-control group), in contrast was not much exposed to extreme cold and prolonged darkness. Moreover, their performance might have been assessed before the initial euphoria to novel environment had passed away or the process of adjustment to novel environmental had begun. This is a possible source for the observed difference in the accuracy of spatial discrimination between the winter and the summer sessions.

However, a greater difference on spatial discrimination between the winter and the summer sessions indicates that adjustment to the unfamiliar environment, where the normal spatial cues are lacking, affects perceptual functioning (Suedfeld, 1987). Nevertheless, lack of marked changes on spatial discrimination in the winter session signifies that the degree of environmental effects on perception does not vary over prolonged duration in unusual or unfamiliar environment.

In short, the significant difference on spatial discrimination between the winter and the summer sessions suggests that the absence of spatial or distance cues as well as prolonged excessive or insufficient bright light affects spatial discrimination. The lack of marked changes on Müller-Lyer illusion in the winter session as well as between the winter and the summer sessions indicate that size constancy is unaffected by unusual viewing conditions, irrespective of duration, in extreme and unusual environment.

Psychomotor performance seems to be intact as no significant decline was found in tasks of two-hand coordination, finger dexterity and hand steadiness. In fact, the performance found increased at post-winter session on hand steadiness and two-hand coordination. There are some studies that support the finding that psychomotor performance does not deteriorate in extreme and unusual environment (for example, Lockhart, 1966). Nevertheless, there are several studies reporting poorer manual performance in cold and extreme environment (Clark, 1961; Lockhart, 1966 and 1968; Le Blanc, 1955; Bensel and Lockhart, 1974). Also, little study are available that have noted improvement, if any, on psychomotor performance. The present study is negating the available reports and this may be attributed to the limitation in conducting the study.

Given that psychomotor performance increased rather than decreased in extreme cold and unusual environment should not be led to the conclusion that psychomotor performance are facilitated or uninfluenced in the unusual environment. It is important to consider here that tests were administered in a cozy environment that did not signify the a typical or extreme conditions. Subjects were tested under temperature of +18 to +22 degree Celsius, with protective clothes. Hence, it is possible that this limitation of the study may have impeded in determining performance in actual environment. The other possible causes for no reduction and improved performance may be the familiarity of the test on retest, environmental adaptation owing to prolonged duration and high motivation of self-selected individuals who volunteered to perform these tests.

In sum, it has been observed that mental speed, vigilance, and visual recognition memory improves and short-term memory for digit remains stable over long-duration of residence in polar environment. Though supported by earlier evidence, further studies need to substantiate the finding with control for environmental and sample characteristics. This study also elucidated the environmental effects on perceptual functioning, as well as the perceptual adjustment to extreme and unusual environment of Antarctica. The findings, however, need further support, as empirical studies on perceptual processes in extreme and unusual environment are thinly available to substantiate. Finally, it would be futile to draw any conclusion from this study on psychomotor performance. Nevertheless, it is explicit that psychomotor performance may be kept intact even in extreme climatic conditions if furnished with improved technology and increased luxury of accommodations.

CONCLUSION

This study has determined that cognitive and psychomotor performance improves during long-term residence in isolated and extreme environment. Perceptual function is unaffected during prolonged winter in Antarctica. However, there is significant difference between winter-over and summer personnel in spatial discrimination ability. It may be said that positive effects outweighed the risks present in prolonged residence in isolated and extreme environment. The present study has brought forth additional evidence on the positive effect in personnel who stay for long duration in isolated and extreme environment.

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Müller-Lyer Illusion test to winter-over participant

Spatial discrimination test to winter-over participant