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SUMMARY

Thirty-two male and female U. S. Marines Corps personnel performed computer controlled tasks for four hour periods, with and without wearing the M17A2 gas mask. Slight deterioration in simple reaction time and speed of button pressing were present when the mask was worn. There were no effects on accuracy. These changes are statistically significant, but they are very small.

INTRODUCTION

Military and civilian workers occasionally have to wear respirators. Gas masks and other filter respirators have been found to change pulmonary function (Kelly, T.L., Yeager, J.E., Sucec, A.A., Ryman, D., Englund, C.E., and Smith, D.A., 1987; Raven, 1980; Raven, P.B., Dodson, A.T., and Davis, T.O., 1979), to decrease endurance (Craig, F.N., Blevins, W.V., and Cummings, E.G., 1970; Stemler and Craig, 1977), and to have deleterious psychological effects, (Brooks, F.R., Xenakis, S.N., Ebner, D.G., and Balson, P.M., 1983; Carter and Cammermeyer, 1985; Morgan, 1983).

Previous studies of masks under non-exercise conditions have found changes in both speed and accuracy of performance (Johnson and Sleeper, 1986; Rauch, 1987; Spioch, F.M., Kobza, R., and Rump, S., 1962). This report discusses the effects of the Mark 17A2 mask worn over a four hour period on speed and accuracy in performing several sedentary tasks.

METHODS

Thirty-two healthy volunteer U. S. Marine Corps personnel (24 males and 8 females) served as subjects (see Table 1 for subject characteristics). Subjects performed a series of computer administered tasks on two 4 hour days. Data was lost on some tests on a few subjects because of equipment failure or subjects failing to understand the task. A randomized crossover design was used, with half the subjects wearing the mask on the first day and half on the second. Half the subjects were tested in the mornings and half in the afternoons. Standard military fatigues were worn during all trials. For the masked condition the M17A2 gas mask was modified (Figure 1) to allow exhaled gas to be measured (results to be presented elsewhere). A one-way valve prevented inhalation through the modified frontpiece, so subjects breathed through the mask as they would in an unaltered M17A2 (in through the input filters and out through the output valve). Masks were adjusted to a snug but comfortable fit at the start of each day. Lack of inward leakage was confirmed by having the subject forcibly inhale with the input filters occluded.

During the four 1 hour sessions on each day subjects alternated every half hour between a long term alphanumeric visual vigilance task (ALPHA),

TABLE 1 - POPULATION CHARACTERISTICS

MALES

	MEAN	SD	MIN	MAX	% PREDICTED	N
AGE (YEARS)	24.7	4.4	18	34		24
WEIGHT (KG)	76.7	9.0	54.1	92.2		24
HEIGHT (CM)	174.8	6.1	160.0	188.0		24
% BODY FAT	15.7	5.3	6.3	24.9		24
FVC (LITER)	5.2	0.9	3.3	6.9	98	24
FEV1 (LITER)	4.0	0.7	2.7	5.3	93	24
YEARS SERVICE	5.4	3.9	1.0	15		24
PAY GRADE	4.4	1.1	3	7		24

FEMALES

	MEAN	SD	MIN	MAX	% PREDICTED	N
AGE (YEARS)	21.0	3.8	18	29		8
WEIGHT (KG)	66.6	12.6	52.1	86.3		8
HEIGHT (CM)	166.7	9.8	154.9	180.0		8
% BODY FAT	28.6	4.4	22.6	33.2		8
FVC (LITER)	4.0	0.4	3.5	4.5	97	8
FEV1 (LITER)	3.3	0.3	2.9	3.7	99	8
YEARS SERVICE	2.3	3.4	0.5	10.0		7*
PAY GRADE	3.0	1.4	2	6		7*

SD = standard deviation
MIN = minimum
MAX = maximum
N = number of subjects on whom measurements were available
KG = kilograms
CM = centimeters
% Body Fat = percent body fat, derived from neck and abdominal circumferences for males and from neck, abdominal, and hip circumferences for females (Hodgdon and Beckett, 1984)
FVC = forced vital capacity
FEV1 = forced expiratory volume in one second

*Data not available on one subject for these measures.

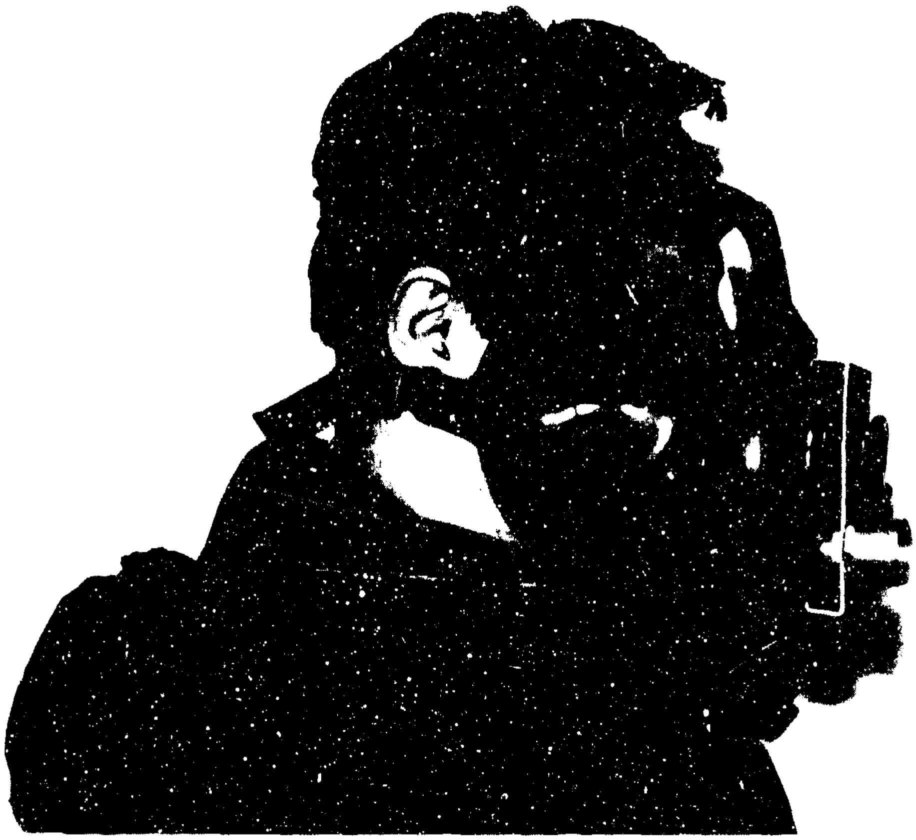

Figure 1: M17A2 MASK WITH ADAPTER

involving responding to a specific letter or number, and a computer administered performance assessment battery (PAB) including: task of reciprocal alternation performance (TRAP), a simple reaction time test (SRT), a four choice reaction time test (FOUR), a logical reasoning test (LOGIC), and a mood, fatigue, and symptom questionnaire (MOOD). These tests are described in detail elsewhere (Ryman, D.H., Naitoh, P., and Englund, C.E., 1984). ALPHA, SRT, and MOOD were given hourly (every session), while FOUR, TRAP, and LOGIC were given every other hour (twice each day of testing). The tasks required constant attention but no activity more strenuous than pressing buttons. All tasks were performed while seated in a comfortable chair in a quiet room with an ambient temperature of approximately 70°F and a relative humidity of about 60%.

Statistical analysis was performed using the SPSS-X statistical package (SPSS, 1983) on a VAX computer. Masked versus unmasked performances were compared using paired 2-tailed t-tests. Multivariate analyses of variance (SPSS, 1983) were done on the SRT and ALPHA data to separate mask effects from possible confounding or interactive effects of variation over the sessions, whether the mask was worn the first or second day, and whether sessions were in the morning or afternoon. Males and females were compared with unpaired 2-tailed t-tests. In tests of response speed (TRAP, FOUR, and SRT), omitted responses were defined as no response within 2.5 seconds. These were treated as reaction times of 2.5 seconds in determining mean and slowest response speeds. In the LOGIC task, subjects who clearly failed to comprehend the task (got no more correct than would occur by chance) were excluded from the analysis. The level for statistically significant differences was set at $p \leq .05$.

RESULTS

Mask vs Control Performances

Results are summarized in Table 2. The mean simple reaction times were slower when subjects wore the mask as compared to the control condition. This difference was also seen when only the 10% fastest responses were used for analysis. There was a decrease in the total number of button presses per session in the TRAP task when the mask was worn. The amount of performance

TABLE 2 - MASK AND CONTROL SCORES (mean ± standard deviation, milliseconds)

	MASK MEAN	± SD	NO MASK MEAN	± SD	t	df	p
SRT							
MEAN	254	35	238	32	-2.88	31	.007
10% FASTEST	178	18	171	16	-2.78	31	.009
10% SLOWEST	460	152	423	109	-1.49	31	.147
FOUR CHOICE							
MEAN	683	85	669	64	-0.72	28[a]	.477
10% FASTEST	417	63	428	57	0.64	28	.526
10% SLOWEST	1331	247	1319	172	-0.24	28	.811
%CORRECT	90	9	92	5	1.12	28	.273
TRAP							
#PRESSES	1268	208	1320	178	2.10	29[b]	.045
10% FASTEST	209	39	205	35	-0.67	29	.511
10% SLOWEST	563	160	531	141	-1.19	29	.254
LOGIC							
#ATTEMPTED	36	11	33	9	0.66	17[c]	.516
%CORRECT	87	12	86	11	0.17	17	.868
ALPHA							
%CORRECT	91	8	89	10	1.36	31	.183

[a]Data lost on 3 subjects due to equipment failure.
[b]Data lost on 2 subjects due to equipment failure.
[c]Data excluded on 14 subjects who showed lack of comprehension of the task (got less than a random number correct).

SRT = simple reaction time task
10% FASTEST = the reaction times in the fastest 10% of trials in a session
10% SLOWEST = the reaction times in the slowest 10% of trials in a session (includes omissions which are treated as 2.5 sec reaction times)
FOUR CHOICE = complex reaction time task
%CORRECT = percent of the total number of responses that were correct
TRAP = task of reciprocal alternating tapping
#PRESSES = number of times the buttons were pressed per session
LOGIC = logical reasoning task
#ATTEMPTED = number of logic questions answered per session
ALPHA = alphanumeric vigilence task

decrement did not correlate significantly with the number of years in service, age, or amount of previous experience with gas masks. There were no effects on speed in any of the other tasks employed and no effects on accuracy in any task.

Trends and Interactive Effects

The mean SRT reaction times showed a linear increase over both days ($F_{sess}(3,23)=6.52$, $p=.002$; $F_{lin}(1,25)=10.25$, $p=.004$). The 10% fastest SRT reaction times showed a cubic trend, with an initial sharp increase followed by a smaller drop and leveling out ($F_{sess}(3,23)=7.50$, $p=.001$; $F_{cubic}(1,25)=9.70$, $p=.005$).

Analysis of variance also demonstrated some interaction of experimental conditions. Both the mean and the 10% fastest SRT reaction times showed a three-way interaction of condition order by morning-afternoon by mask-no mask ($F_{mean}(1,25)=5.77$, $p=.024$; $F_{fast}(1,25)=9.83$, $p=.004$). In both these measures the subjects tested in the morning who wore the mask on day 2 showed the largest decrements with the mask, while afternoon subjects who wore the mask on day 1 actually showed faster reaction times with the mask.

Gender Differences

In the TRAP task males showed more total presses per session in the unmasked state than females (1359 vs 1213 msec, $t=-3.15$, $df=27.88^*$, $p=.004$). In the ALPHA vigilance task females showed fewer errors of commission (button presses to non-target signals) in the masked state than males (0.4 vs 0.8, $t=-2.27$, $df=29.08^*$, $p=.031$).

The amount of change between the unmasked and masked results was similar for males and females on all measures except the 10% slowest response times for the FOUR task. Males were slightly (not significantly) slower than females in the unmasked state on this measure. Males improved slightly in the mask, while females performed less well, so that males were (again, not

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*Degrees of freedom is a non-integer number as separate rather than pooled variance was used because of significantly different group variances (Blalock, 1972).

significantly) faster than females in the masked state. When the amounts of change were compared, these moves in opposite directions added up to a barely significant difference (females were 175 msec slower in the mask, while males were 49 msec faster, t=-2.07, df=27, p=.048).

When unmasked vs masked performances were examined in males and females separately, more differences were found. Among the male subjects, there were two significant mask effects. The mean SRT response times were slower (252 vs 237 msec, t=-2.10, df=23, p=.047), and there was a decrease in the mean number of button presses per session in the TRAP task (1284 vs 1359, t=2.82, df=21, p=.010). Females showed prolongation of both mean and fastest SRT response times (mean: 259 vs 240 msec, t=-2.64, df=7, p=.034; fastest: 185 vs 175 msec, t=-2.94, df=7, p=.021), and in the slowest responses on the FOUR task (1459 vs 1285 msec, t=-3.05, df=7, p=.019). Females did not show an effect on the TRAP task.

DISCUSSION

There has been little investigation into the effects of masks on non-aerobic activities. Spioch et al. (1962) studied subjects performing the Bourdan psychotechnical test. They found that wearing a protective mask led to an increase in committed errors and an increase in the time needed to perform the task. Johnson and Sleeper (1986) studied the effects of wearing the M17A1 mask plus hood, with and without the standard butyl rubber gloves, on performance of manual dexterity tasks. They found that the gloves did slow task performance, but the mask caused no separate effect. Rauch (1987) looked at the effects of mask and/or gloves on performance of math computations. Only the mask and gloves, or gloves alone, showed significant differences from control. However, there was a trend to a mask effect, with the mask performances falling between control and gloved.

Rauch, T.M., Witt, C., and Banderet, L. (1986) studied the effects of various ensembles of chemical protective clothing on a series of cognitive problem solving tasks. They found that the highest MOPP level (the only level including mask and gloves) caused significant deterioration in speed of performance without affecting accuracy. The effects of mask without gloves were not studied.

Kobrick and Sleeper (1986) observed the effect of MOPP gear, with or without a hot humid environment, on reaction times to stimuli in various parts of the visual field. This probably included an M17A series mask as this was a U.S. Army project using standard army gear. MOPP gear caused significant prolongation of reaction time, as compared to a control condition of standard battle dress, with additional deterioration under the hot humid condition. Again, the effects of the mask were not looked at separately.

The predominant lack of change with the mask in the present study corresponds with the findings of Johnson and Sleeper (1986), Rauch et al. (1986), and Rauch (1987). The findings of slowed responses in the SRT and TRAP tasks agree with Kobrick and Sleeper (1986). The task used in that study is somewhat analogous to, but more complex than, our SRT test. Peripheral vision was important in that task while it was not in ours. They attribute their findings to effects of the mask but, since the mask was not studied alone, this is uncertain. The SRT and TRAP slowing are also consistent with Spioch et al. (1962), who found both decreased accuracy and slowing when a mask was worn without other equipment. However, the task they used was "a test based on the accuracy and time required for a [subject] to strike out certain letters, numbers, or words" (Dorland, 1981). This is quite different from all of our tasks. In future studies we will be incorporating a variety of additional tasks to evaluate effects on a broader range of performance characteristics.

The linear trend of deterioration in mean SRT reaction times seems most likely related to fatigue or boredom. The authors have no good explanation for the cubic trend in fastest SRT reaction times, with a marked deterioration from the first to the second session. There was a complex interaction of condition order by time of day by condition. The morning group who wore the mask the second day appear to have amplification of the expected decrement while the afternoon group who wore the mask the first day showed their best performances in the mask. These latter subjects may have been bored by the second day under the no mask condition. The remaining subjects showed only very small differences between the unmasked and masked conditions. Why there would be such a significant time-of-day by experimental condition order effect is unclear. It may relate to some circadian rhythm in performance or learning.

We have found no previous studies addressing male female response differences in masks without other gear. Hamilton and Zapata (1983) reported gender related response differences when the complete U.S. aircrew chemical defense ensemble (M-24 mask, helmet, hood, protective suit, butyl rubber gloves, and butyl rubber boot covers) was worn for 6 hours. They found trends for females to be more affected than males. Females tended to have more mood deterioration, more increase in reaction times, and more decrease in accuracy when they wore the suit. The present study agrees with these results, suggesting that females were more affected by the mask than males, at least in reaction times. The male subjects had more previous experience wearing the masks and other protective clothing than the females did (14.7 vs 1.0 hour). However, this difference was not significant by t-test, probably because of totally different variances in the two groups. All 5 female subjects that we had this information on had each worn a mask only 1 hour previously, while previous chemical defense experience in males ranged from 0 to 3000 hours. When amount of previous experience (or a partial log conversion, using -.1 when there were 0 hours experience) was plotted against the amounts of change seen with the mask, there were no significant correlations, indicating that changes in performance in the mask condition did not relate to experience. On the SRT task the male subjects were often noted to be competing, comparing fastest scores after each session. Female subjects did not seem to do this. It is possible that the motivation from competition between the masked and unmasked subjects served to obscure deleterious effects of the mask on the fastest responses on the SRT task among males. However, there was no feedback on the FOUR task, so this cannot be the explanation in that case.

CONCLUSION

Wearing the M17A2 gas mask while performing a series of sedentary tasks was associated with small detrimental effects on reaction times and speed of alternation between two buttons. There were no effects on accuracy in any of the tasks. All the decrements seen were small and not affected by previous experience with the mask. We conclude that wearing the M17A2 mask over moderate time periods should not interfere with male or female soldiers fulfilling most sedentary duties.

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Volunteer U. S. Marine Corps personnel (24 males and 8 females) participated in a randomized crossover design experiment studying effects of the M17A2 gas mask on speed and accuracy of performance in a series of non-exercise computer controlled tasks. A test of simple reaction time (SRT) showed small decrements in speed of response (mean mask reaction time 254 vs no mask 238 msec, p=.007; fastest mask reaction times 178 vs no mask 171 msec, p=.009). A task requiring the subject to rapidly alternate between pressing two buttons showed a small decrease in the number of presses achieved per session (1268 vs 1320, p=.045). A more complex reaction time task, visual vigilance, and logical reasoning showed no changes in speed or accuracy when the mask was worn. When the male and female data were analyzed separately, the effects on SRT were only significant among females, while the effects on TRAP were only significant in males. Females also showed a decrement in the slowest responses in the complex reaction time task.

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