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The Effects of Single and Repeated Doses of Oral Scopolamine, Cinnarizine, and Placebo upon Psychological Performance and Physiological Functioning

A. C. PARROTT*, J. F. GOLDING† and R. J. PETHYBRIDGE
Institute of Naval Medicine, Gosport, Hampshire PO12 2DL, UK

The present study was one in a series in the Institute of Naval Medicine's Motion Illness Project. A battery of psychological performance tests (producing 26 indices of mental and hand–eye co-ordination), together with visual near fixation point, resting heart rate and a self-rated feeling state questionnaire, were used to compare the effects of thrice-daily oral doses of scopolamine (0·6 mg), cinnarizine (30 mg) and a lactose placebo in a double-blind crossover trial on 12 healthy male volunteers. Measurements were made 1–2 h and 5–6 h after the initial dose, then the next day following the last successive dose (1–2 and 5–6 h after the fourth dose; or 25–26 and 29–30 h after the initial dose). Scopolamine demonstrated clear physiological effects, with reduced heart rate from the first oral dose onwards, and visual near-point values increasingly distant over successive doses. Cinnarizine did not produce significant physiological changes. Neither drug produced significant effects on subjective mood. Significant ANOVA drug effects or drug × time interaction effects were present with five out of the 26 performance variables: logical reasoning error, memory word-recall errors; continuous four choice reaction time; concept identification time; SERS task commission error. However only two of these (memory error, four choice reaction time) demonstrated patterns of effect which were considered to be attributable to the drugs. Both cinnarizine and scopolamine impaired memory error and four choice reaction time. Only for visual near-point with scopolamine was there evidence that repeated dosing led to increasing physiological/mental performance effects.

KEY WORDS—Scopolamine, Cinnarizine, Psychomotor performance, Mental processes, Vision, Motion sickness.

INTRODUCTION

Scopolamine (hyoscine) has been demonstrated to be an effective drug for protection against motion illness (Brand and Perry, 1966; Wood and Graybiel, 1972). However, scopolamine produces deleterious side-effects upon performance. Decreased alertness, memory and attention have been reported from investigations into the effects of single doses (Payne *et al.*, 1952; Elkin *et al.*, 1965; Crow and Grove-White, 1973; Wesnes and Warburton, 1983; Parrott, 1986a). The deleterious effects of scopolamine upon performance were maximal 1–2 h following drug administration (Elkin *et al.*, 1965; Parrott, 1986a). An alternative drug, cinnarizine, has been demonstrated to provide protection against motion illness. The degree of protection was less than that provided by scopolamine (Wood and Graybiel, 1972; Stott *et al.*, 1984), although one recent study has demonstrated equivalent efficacy between cinnarizine and scopolamine (Pingree *et al.*, 1988). However, the effects of cinnarizine upon psychological functions and performance have been investigated rarely. Stott *et al.* (1984) found no significant performance changes 1–2 h following 15 mg oral cinnarizine. Parrott and Wesnes (1987) demonstrated decrements on several tasks 5–6 h, but not 1–2 h, following administration of 30 mg oral cinnarizine.

These performance side-effect investigations were concerned with the effects of single-drug administrations; the effects of repeated doses of oral scopolamine or cinnarizine upon performance do not seem to have been undertaken previously. However, in many situations anti-motion illness drugs are taken repeatedly at sea where adverse motion conditions may remain for long periods. The effects of a single-drug administration may be different from those of repeated drug administrations; they may increase with time, decrease if

† Correspondence to Dr J. F. Golding, Institute of Aviation Medicine, Farnborough, Hampshire GU14 6SZ, UK.
* Dr A. C. Parrott is now at the Department of Psychology, North East London Polytechnic, Romford Road, London E15 4LZ, UK.

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adaptation occurs or remain basically unchanged. The trial reported here assessed the effects of repeated doses, and also allowed a direct comparison between the effects of single and repeated doses.

Visual problems have been reported following both oral and transdermal hyoscine (Lukomskya, 1971; Parrott and Jones, 1985; Parrott, 1986b), with blurred vision, and impaired visual near-point focusing reported. These problems increase in frequency following successive transdermal scopolamine patches, with more subjects developing blurred vision, and a steady increase in visual near-point (Parrott, 1986b). Although Glaser (1953) reported that almost all side-effects decreased in frequency over time following 0·5 mg thrice-daily oral hyoscine for 4 days, there was an increase in blurred vision over this period. The possible effects of cinnarizine upon visual functions do not seem to have been previously investigated, with either single or repeated dose conditions. The present study was one of a series in the Institute of Naval Medicine's Motion Illness Project.

METHODS

Subjects

Twelve medically fit, fully briefed, male volunteers (age range 20–26; median 21 years) were used. They were medically screened before trial commencement. Informed consent forms were signed by all subjects in accordance with the Helsinki Agreement.

Assessment measures

Four choice reaction time (Wilkinson continuous reaction time). A set of four LED stimulus lights had a group of four corresponding response keys. On stimulus illumination the correct response key was pressed. A second stimulus light became instantly illuminated, and a second response was immediately required. Subjects worked as quickly and accurately as possible. Total correct responses and errors were recorded.

Target tracking (fine psychomotor co-ordination). The target was situated in the middle of the computer display. The stimulus (a small cross) was programmed to move randomly around the screen; its position could be changed by means of a joystick. The subject attempted to keep the stimulus centred on the target by means of compensatory control movements with the joystick, i.e. average distance between target and stimulus. Root mean square error was automatically calculated.

Letter cancellation (one or four letters; information processing requiring sustained attention). The subject scanned rows of randomly arranged letters, and with a coloured pen cancelled each instance of a target letter (or four letters). The target letter (or letters) was defined at the top of the page. The number of letters scanned, and total errors, were recorded.

Code substitution (information processing task). A nine-item letter/digit code was presented at the top of the VDU screen. The subject encoded a series of randomly appearing letters, by pressing the appropriate digit on the numeric keypad. The average time per coding, and percentage errors, were automatically calculated (Apple IIe computer).

Stimulus evaluation and response selection (SERS – reaction time). This represented a discrete four choice reaction time task, with easy and hard stimuli, and catch trials (without stimuli). Mean reaction times, and percentage errors, were automatically recorded (Apple IIe computer).

Number facility (mental arithmetic). Five two-digit numbers were added together, and the answer entered via the numeric keypad. Mean response times, and percentage errors, were automatically recorded (Apple IIe computer).

Concept identification test (thinking and problem-solving). Sets of four line-drawings were scanned, and the probabilistic 'concept' within the set of drawings identified. Mean problem solution times, and error rates, at each of four difficulty levels, were calculated (RML 380Z computer).

Visual reaction time test (basic psychomotor speed, width of stimulus scanning). Stimulus targets (x's) appeared on the VDU screen at random times, and in various central and peripheral positions. All stimuli required the same bar press response. Mean reaction times, and central-peripheral stimulus percentage reaction time difference scores, were automatically calculated (Apple IIe computer).

Memory storage (after Ghoneim and Mewaldt, 1975). Four lists of 16 tape-recorded words were presented, at a rate of one word every 2 s. Following the presentation of each list, written recall of as many words as possible was required. Total correct recall, and commission errors, were calculated. Following an intervening period (when other tasks were performed), delay written recall of the words from all four lists was required. Again, total correct recall, and commission errors, were calculated.

Logical reasoning (Baddeley A–B reasoning test,

a measure of cognitive processing ability). Logical statements were presented in a standardized format, and were either true or false. Subjects made their judgement on each statement as quickly as possible. Percentage correct responses, and average response times, were each calculated (Apple IIe computer).

Subjective self-ratings (visual analogue scale (VAS) feeling state questions). Six scales were presented, covering various areas of feeling state (e.g. alertness, sociability). In addition, side-effects such as blurred vision or dry mouth were covered also.

Sleep questionnaire (Leeds VAS self-rating sleep questionnaire). Ten VAS scales were presented, covering three areas of sleep: getting to sleep, quality of sleep and behaviour immediately following sleep.

Visual near fixation point (RAF rule). The near fixation point for each eye was separately assessed using the RAF rule. Subjects reported the nearest point at which the visual text remained in focus; this distance was recorded in centimetres.

Resting heart rate. The basal heart rate of resting subjects was recorded, using peripheral (finger) photoplethysmography.

The 12 performance tests were performed in counterbalanced rotation (Latin square), by the 12 subjects. Each test was 4 min in duration, with 1 min changeover between tests. As well as the above individual tests, a group test of memory storage for new information was given (8 min).

Testing sessions. Two testing sessions were given each day, at 1000–1110 h, and 1400–1510 h. They provided information on drug effects 1–2 h and 5–6 h following administration of the previous drug capsule.

Drug conditions: There were three drug conditions as follows:

oral placebo three times daily;
oral scopolamine 0·6 mg three times daily;
oral cinnarizine 30 mg three times daily.

Drug administration was at 0900, 1600, and 2300 h. Drug administration and testing was double-blind. The order of drug administration was based on a three-way Latin square (replicated).

Data analysis. The data were analysed by Latin square analyses of variance (ANOVA) for repeated measures, with the following factors:

group (1, 2, 3);
test order (week 1, 2, 3);
drug condition (placebo, hyoscine, cinnarizine);
test session within week (session 1, 2, 3, 4).

The design allows for assessment of the main effects of 'groups', 'test order', 'drug condition', 'test session within week', the interactions of (a) 'group' with 'test session within week', (b) 'drug condition' with 'test session within week', and partial interactions of 'drug condition' with 'test order', and the interaction of 'test session with week' with the partial interaction of 'drug condition with test order'. The percentage error data was subjected to angular transformation.

PROCEDURE

During the Wednesdays and Thursdays of each week, drug administration was thrice-daily each day (see 'Drug conditions'). Test sessions 1 and 2 on the Wednesdays (1000–1100 h; 1400–1500 h) provided data for drug effects 1–2 h and 5–6 h following the first dose (administered at 0900 h). Test sessions 3 and 4 on the Thursdays provided data for drug effects 1–2 h and 5–6 h following the fourth successive dose. Self-rating scales provided data for feelings state (e.g. alertness) throughout each test day. The Friday morning testing (self-ratings, visual near-point, heart rate) provided data after 2 days continuous oral dosing, following a last drug administration at 2300 on Thursday. Drugs were *not* administered on Friday morning. This enabled the subjects to be safely discharged by Friday early afternoon. They returned the following Tuesday afternoon, for refresher tests.

The trial was carried out in the Environmental Medicine Unit of the Institute of Naval Medicine. Temperature was maintained at 22 (±2)°C centigrade dry bulb (reduced to 20°C at night), and relative humidity was maintained at 55 per cent (±10 per cent). Alcohol consumption was not allowed, nor were caffeine-containing beverages permitted, but decaffeinated coffee was freely available. Smoking was not permitted ½ h before, or during, testing. TV, video, cassette-radio, snooker, and various board games were available for relaxation. The research suite was covered by a 24 h watch.

RESULTS

Group mean values for each drug condition at each test session, are presented in Tables 1–3. Table 1 (a–f) presents the data for the psychological performance assessments; Table 2 presents the physio-

Table 1(a). Group mean values for the performance assessment measures

Assessment measure	Hours following first drug administration	Drug condition		
		Placebo	Cinnarizine	Scopolamine
Code substitution reaction time (s)	1–2	1·88	1·87	1·96
	5–6	1·80	1·84	1·82
	25–26	1·80	1·72	1·81
	29–30	1·73	1·78	1·75
Code substitution error (%)	1–2	2·4	1·8	2·5
	5–6	1·9	2·7	1·8
	25–25	2·4	1·9	3·0
	29–30	2·6	2·8	2·4
Logical reasoning reaction time (s)	1–2	3·93	3·90	3·51
	5–6	3·60	3·77	3·37
	25–26	3·54	3·47	3·32
	29–30	3·05	3·47	3·04
Logical reasoning error (%)	1–2	5·4	6·7	5·0
	5–6	6·9	6·3	3·7
	25–26	5·3	3·6	4·7
	29–30	5·3	6·0	5·7

logical assessment measures; Table 3 presents the feeling state questionnaire findings. The ANOVA findings are summarized in Table 4(a) and 4(b).

Of the 26 performance tests (excluding visual near-point, heart rate and mood ratings) itemized in Table 4(a) only five indicated any significant differences between drug profiles. These five tests were logical reasoning (errors), memory word recall (errors), four choice reaction time (RT), concept identification (RT hard) and stimulus evaluation response selection (SERS easy CE). On examination of these five tests it was found that subjects performed worse under cinnarizine relative to placebo for memory errors and for four choice reac-

Table 1(b). Group mean values for the performance assessment measures

Assessment measure	Hours following first drug administration	Drug condition		
		Placebo	Cinnarizine	Scopolamine
One-letter cancellation reaction time (s)	1–2	0·13	0·13	0·14
	5–6	0·11	0·12	0·11
	25–26	0·14	0·13	0·13
	29–30	0·12	0·12	0·12
One-letter cancellation error (%)	1–2	8	9	12
	5–6	7	9	5
	25–26	15	14	17
	29–30	12	14	13
Four-letter cancellation reaction time (%)	1–2	0·33	0·36	0·34
	5–6	0·34	0·33	0·33
	25–26	0·33	0·32	0·32
	29–30	0·30	0·33	0·31
Four letter cancellation error (%)	1–2	22	18	23
	5–6	18	22	22
	25–26	16	21	20
	29–30	20	22	19

Table 1(c). Group mean values for the performance assessment measures

Assessment measure	Hours following first drug administration	Drug condition		
		Placebo	Cinnarizine	Scopolamine
Memory errors (words not recalled)	1–2	33·3	37·8	34·6
	5–6	32·1	38·1	33·4
	25–26	33·3	34·1	36·8
	29–30	34·1	35·1	34·9
Memory errors (commission)	1–2	2·1	2·2	2·1
	5–6	1·1	1·3	1·4
	25–26	1·6	2·2	2·8
	29–30	2·3	1·8	3·5
Mathematics response time (s)	1–2	17·6	17·1	18·1
	5–6	16·7	16·0	16·9
	25–26	16·1	15·6	16·2
	29–30	15·8	15·6	15·2
Mathematics errors (%)	1–2	14	10	11
	5–6	13	12	6
	26–26	14	13	12
	29–30	16	13	10

tion time. Similarly, subjects performed worse under scopolamine relative to placebo for memory errors and for four choice reaction time. In the other three of the five tests, although there were significant ANOVA drug × time or drug effects, the patterns were not easy to explain in terms of consistent drug action (Table 1).

For those performance tests showing significant drug × time ANOVA interactions, the data demonstrated no consistent differences in performance between the first two test sessions (following a single oral dose), and the third and fourth test sessions (following four successive oral doses). In other words, change between sessions 1 and 2 versus

Table 1(d). Group mean values for the performance assessment measures

Assessment measure	Hours following first drug administration	Drug condition		
		Placebo	Cinnarizine	Scopolamine
Four-choice reaction time (s)	1–2	0·53	0·52	0·55
	5–6	0·53	0·54	0·53
	25–26	0·52	0·52	0·53
	29–30	0·51	0·54	0·50
Four-choice reaction time commission error (total)	1–2	22	15	18
	5–6	20	18	20
	25–26	18	20	20
	29–30	19	27	24
Visual reaction time (2)	1–2	0·36	0·37	0·39
	5–6	0·35	0·38	0·36
	25–26	0·35	0·36	0·37
	29–30	0·36	0·37	0·35
Visual reaction time (central–peripheral stimulus percentage difference)	1–2	2	3	3
	5–6	5	3	3
	25–26	3	0	3
	29–30	3	2	2

Table 1(e). Group mean values for the performance assessment measures

Assessment measure	Hours following first drug administration	Drug condition		
		Placebo	Cinnarizine	Scopolamine
Concept identification response time (easy problems)	1–2	10·2	10·2	11·5
	5–6	10·0	10·7	9·8
	25–26	9·0	9·5	9·4
	29–30	8·6	9·9	9·6
Concept identification response time (2nd easy)	1–2	10·5	10·3	12·5
	5–6	11·5	11·6	13·1
	25–26	10·0	11·1	10·8
	29–30	10·1	11·2	9·9
Concept identification response time (2nd hard)	1–2	13·5	13·8	12·0
	5–6	12·5	12·3	11·6
	25–26	11·4	14·8	11·8
	29–30	14·0	14·7	10·3
Concept identification response time (hard problems)	1–2	14·8	12·8	19·2
	5–6	14·4	14·3	13·0
	25–26	13·7	15·7	15·0
	29–30	14·8	14·0	22·4
Concept identification error (%) (all problems)	1–2	5	9	6
	5–6	8	7	6
	25–26	6	7	6
	29–30	5	7	6

Table 1(f). Group mean values for the performance assessment measures

Assessment measure	Hours following first drug administration	Drug condition		
		Placebo	Cinnarizine	Scopolamine
Target tracking (r.m.s. error)	1–2	9·5	9·7	12·1
	5–6	9·5	11·5	8·6
	25–26	10·6	11·9	8·6
	29–30	10·4	7·5	8·8
SERS task response time (easy stimuli)	1–2	0·90	0·90	0·90
	5–6	0·89	0·94	0·91
	25–26	0·90	0·90	0·88
	29–30	0·88	0·94	0·87
SERS task response time (hard stimuli)	1–2	1·00	0·99	1·00
	5–6	0·98	1·01	0·98
	25–26	0·97	0·97	0·94
	29–30	0·97	0·98	0·91
SERS task commission error (easy stimuli)	1–2	3	8	8
	5–6	4	3	2
	25–26	12	2	3
	29–30	1	9	5
SERS task commission error (hard stimuli)	1–2	2	2	4
	5–6	4	4	1
	25–26	5	6	3
	29–30	5	8	4

Table 2. Group mean values for the physiological assessment measures

Assessment measure	Hours following first drug administration	Drug condition		
		Placebo	Cinnarizine	Scopolamine
Visual near-point (CM)	1–2	14·6	15·3	14·1
	5–6	15·1	15·5	14·1
	25–26	14·8	15·4	15·5
	29–30	14·9	15·3	16·3
	47	15·4	15·6	16·0
Resting heart rate (b.p.m.)	1–2	67	69	60
	5–6	70	72	68
	25–26	70	74	61
	29–30	75	75	66
	47	82	90	77

change between sessions 3 and 4 were broadly comparable for a given drug. The performance changes which were evident neither consistently decreased in severity, nor consistently increased in severity, between those test sessions.

With scopolamine, visual near-point values increased following successive doses (Table 2). Heart rate was also significantly lower with scopolamine (Table 2). With cinnarizine, visual near-point values and resting heart rate values remained close to those found under placebo. The only marked difference was a raised heart rate value at the last test session (47 h after the first cinnarizine dose, and 10 h after the last cinnarizine dose; Table 2). It is not known if this reflects a true drug effect, or a chance (random) effect. With respect to the subjective feeling states, neither self-rated alertness nor sociability were significantly affected by drug conditions. The only noticeable (but not significant) changes were reduced feelings of alertness and sociability 1–2 hours after the first oral dose of scopolamine (Table 3).

DISCUSSION

The present study used a complex design, involving two post-drug test session 1–2 h and 5–6 h after the first oral dose, and two further test sessions follow-

Table 3. Group mean values for the subjective feeling state questions

Assessment measure	Hours following first drug administration	Drug condition		
		Placebo	Cinnarizine	Scopolamine
Self-rated sociability (CM)	1–2	58	54	47
	5–6	51	52	52
	14	54	49	53
	23	47	52	50
	25–26	54	52	54
	29–30	56	58	51
	38	60	55	55
	47	53	54	56
Self-rated alertness (CM)	1–2	45	44	37
	5–6	40	39	43
	14	49	41	42
	23	39	44	44
	25–26	46	45	43
	29–30	55	51	43
	38	55	50	53
	47	47	49	48

Table 4(a). Summary of the analysis (ANOVA) findings (probability values for each factor)

	ANOVA factors						
Assessment measure	Order (O)	Drug (D)	O × D (partial)	Time (T)	O × T	D × T	O × D (partial) × T
Code substitution							
RT				0·01			
ERR							
Logical reasoning							
RT	0·10	0·10		0·01			
ERR						0·05	0·10
One-letter cancellation							
RT	0·05			0·01			
ERR	0·01			0·01	0·01		
Four-letter cancellation							
RT				0·10	0·01		
ERR	0·01				0·01	0·10	
Memory – word recall	0·10	0·10			0·05	0·05	
CE	0·01	0·10		0·05			
Visual reaction time							
RT	0·01						
C/P							
Mathematics							
RT				0·05	0·05		
ERR							
Four-choice reaction time							
RT	0·01		0·05	0·05		0·01	
ERR	0·10			0·10			
Tracking							
RMS							
Concept identification – RT							
Easy	0·05						
2nd Easy	0·05			0·05			
2nd Hard							
Hard	0·01	0·05	0·01		0·10		
All problems – Error							
SERS task							
Easy – RT							
Hard – RT	0·10			0·05	0·10		
Easy – CE					0·10	0·01	
Hard – CE					0·05		

ing the fourth successive dose (25–26 h and 29–30 h after the first dose), which was necessary because of the different pharmacokinetic profiles of scopolamine and cinnarizine. The evidence is limited but it appears that the half-life of scopolamine is comparatively shorter than the half-life of cinnarizine (Morrison *et al.*, 1979; Benson, 1984). A previous study demonstrated larger performance changes 1–2 h and 3–4 h following a single oral dose of scopolamine, compared with performance change 5–6 h after dosing (Parrott and Wesnes, 1987). In contrast, oral cinnarizine produced minimal performance changes 1–2 h and 3–4 h after drug administration, but statistically significant per-

Table 4(b). Summary of the analysis (ANOVA) findings (probability values for each factor)

	ANOVA factors						
Assessment measure	Order (O)	Drug (D)	O × D (partial)	Time (T)	O × T	D × T	O × D (partial) × T
Visual near-point (CM)				0·05		0·05	
Resting heart rate (b.p.m.)		0·01		0·01	0·01	0·10	
Feeling – alertness	0·05			0·01			
States – sociability	0·05		0·10				

Legend: Order = Latin square order of administration; Drug condition; Time = Time following first drug administration.

Note: A groups factor to examine the order of presentation of individual tests within each condition produced no significant main effects and only two minor interactions with time, for SERS commission errors and four-choice RT.

formance decrements 5–6 and 8–9 h after dosing (Parrott and Wesnes, 1987).

The putative different time-course of effects of scopolamine and cinnarizine, described above, was generally not confirmed by this experiment. The performance assessments used in the trial covered a wide range of psychological functions, including psychomotor speed, fine psychomotor skill, continuous performance, sustained attention, memory for new information, information processing, thinking and problem-solving. This task battery included tasks with demonstrated sensitivity to the effects of scopolamine and cinnarizine (Parrott, 1986a; Parrott and Wesnes, 1987). However only five out of the 26 performance indices demonstrated significant ANOVA drug × time or drug effects, and only two of these produced patterns of effect which could be explained in terms of consistent drug action. Both drugs did, however, produce significant decrement on memory and four choice reaction time (Table 1). Neither cinnarizine nor scopolamine produced significant changes in subjective mood (Table 3). With regard to the effects of repeated oral dosing, these in general did not differ from the effects of single doses.

The two physiological measures investigated in the present study (resting heart rate, visual near point), have each been demonstrated to be affected by hyoscine (Elkin *et al.*, 1965; Parrott, 1986a). The present findings confirmed the known effects of hyoscine, and demonstrated that cinnarizine was basically free from deleterious effects upon these physiological indices.

The implications for the 'real-life' situation of the performance deficits observed in this experiment can be considered in relative and absolute terms.

In relative terms the performance deficits produced by scopolamine (0·6 mg, by mouth) versus cinnarizine (30 mg) can be validly compared, given the recent evidence that the drug dosages employed here may be equivalent in terms of their protective efficacy against 'rotating-chair' induced motion illness (Pingree *et al.*, 1988; although see: Wood and Graybiel, 1972; Stott *et al.*, 1984). On this basis the present experiment revealed no clear overall difference, between scopolamine (0·6 mg) and cinnarizine (30 mg), in the overall degree of psychological performance deficits that they induced (but see below for visual effects).

With regard to the physiological measures, the small resting heart rate reduction produced by this dose of scopolamine would probably be swamped by any cardio-acceleration induced by physical exercise, stress, etc. The possibility that scopolamine might affect cardiovascular performance under conditions of extreme physical activity is unlikely since maximal heart rate (e.g. in response to exercise) is not altered by atropine, and by implication also scopolamine (Goodman and Gilman, 1980).

The visual deficits induced by scopolamine (Table 2) would be of importance to personnel requiring peak visual performance, e.g. focusing ability of radar screens; pupil dilation could be deleterious under bright light conditions (pupil dilation was not studied here but is a standard finding). Furthermore, it is important to note that the scopolamine-induced ocular deficits (pupil dilation, near focusing deficit) slowly build up with continued usage of scopolamine, e.g. as delivered by transdermal patches over several days (Parrott, 1986b). Thus, cinnarizine has performance advantages over scopolamine for personnel requiring peak visual performance.

In absolute terms the degree of performance

deficits observed in this experiment, with some mental performance/physiological changes statistically significant, were small compared to the between-individual variation. They were also broadly comparable to the natural diurnal variation as revealed by changes in response over time with 'placebo'. Nevertheless, for individuals who are inherently poorer performers, or under conditions of monotony, or when fatigue and drowsiness are already present, then the additional vigilance-lowering effects of either cinnarizine or scopolamine could have serious consequences, e.g. during watch-keeping tasks at sea, or driving on a monotonous motorway.

CONCLUSIONS

Scopolamine and cinnarizine at approximately equivalent dosages for anti-motion illness efficacy, produced negligible or similar degrees of deficit in psychological performance. In addition, scopolamine produced deficits in close visual focusing which may be of importance for some personnel requiring peak visual performance. There was no evidence that repeated dosing led to mental performance deficits different from those found after single doses.

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