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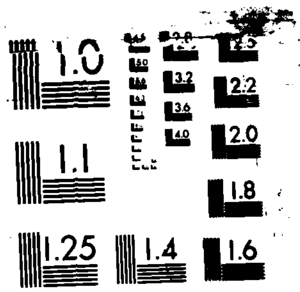

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REPORT

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C.J. Woodruff

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A field experiment is reported in which subjects' expectations regarding cues to detection of selected target types, and the effect such expectations might have on time to detection, were investigated. A scenario procedure for measurement of expectations is described, and the reliability and validity of this procedure documented. A measure of the mismatch between the availability of certain features on individual targets and the subject's expectations is introduced. The variation of search time with mismatch is examined, and it is found that there is no evidence of its dependence on the extent of mismatch.

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ABSTRACT

A field experiment is reported in which subjects' expectations regarding cues to detection of selected target types, and the effect such expectations might have on time to detection, were investigated. A scenario procedure for measurement of expectations is described, and the reliability and validity of this procedure documented. A measure of the mismatch between the availability of certain features on individual targets and the subject's expectations is introduced. The variation of search time with mismatch is examined, and it is found that there is no evidence of its dependence on the extent of mismatch.

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VISUAL SEARCH PERFORMANCE AND OBSERVER EXPECTATIONS

1. INTRODUCTION

Visual search for a heavily obscured target is dependent for its success on the searcher firstly being able to detect a discontinuity of the appropriate type from the target surround. The discontinuity is generally a luminance change, though it may also be a textural edge or chroma edge. The major research problems at this stage concern the thresholds for detection, and are primarily ones of physics and physiology, though thresholds do also depend on the observer's physiological and psychological state.

When a target is supra-threshold, the searcher needs to be able to judge that a particular discontinuity is of a form consistent with some part of what he seeks. This judgement is a cognitive process. At the very least it has required that the subject draw on some memory representation of the visual characteristics of the targets, and make a decision to respond. A number of authors have produced evidence that subjects' expectations about the location or characteristics of a target can increase the error rate when non-targets appear in either the expected location [1], or having some of the defining characteristics of the target [2]. Thus the mental set that an observer brings to a visual search task might be expected to have an effect on the time to detect targets.

Much visual acquisition - including that involved in military visual surveillance - deals with acquisition of targets which are significantly above the detection threshold, yet are quite difficult to acquire. This difficulty arises from a failure to associate a particular discontinuity, feature, or form with the set of objects constituting targets or parts of targets. It is commonly assumed that instructions to attend, or other priming conditions, will lead to improved acquisition performance on the relevant task. Such priming may be interpreted as increasing the subject's expectation for a particular feature or set of features, with the increase in expectation giving an increased likelihood of either becoming aware of a particular feature or responding to it when it is available.

The expectations examined here are those long term mental sets which an observer brings with him, as distinct from those arising from very recent cueing [1], or experimentally induced [3]. Ward[3] manipulated subjects' expectations regarding the size of a target, and showed that, when the target to be detected was of a size markedly different from the preceding one, then response time was greater than when successive targets were of the same size. Ward interpreted this as an attention switching phenomenon. Posner et al. [1] have sought to differentiate between low level orienting responses which are entirely passive and the more extensive processes of detection which allow responding. Posner found that while information on spatial position speeded the detection of suprathreshold targets on plain backgrounds, information on the form of the stimulus did not. It should be noted that the form changes used in the Posner studies did not involve scale changes of the type investigated by Ward, and hence there is no necessary contradiction in their results. The expectancies examined in both of these studies could have been induced by the experimental conditions utilised here, as targets occurred at ranges from 50 metres to 800 metres, and the spatial orienting effects of complex backgrounds are quite undetermined.

In the field experiment reported here, search performance for heavily obscured targets was measured using time of search as the performance criterion. Measures of subjects' expectations for particular target features under various obscuration conditions were obtained, and the reported actual availability of target features for each target was found. If search performance in this task depends on the subject's expectation for specific features then search time would depend on the product of expectation level for a particular feature and the actual availability of that feature. It was this dependence which was examined.

Three types of data were collected - expected causes of detection, search times to detection and/or recognition, and reported causes of actual detection. Procedures for collecting and analysing each type of data will be described separately, followed by an analysis of the relation between search time, expected causes, and reported causes.

2. MEASURING EXPECTATIONS

In a pilot study on expected causes of detection, Woodruff and Webb[4] had found that subjects' expectations could be described in terms of four factors:-

i. bulk, in contrast to shine;

ii. protruding line shapes such as aerials, supports, and guns;

iii. near-ground shadows such as wheel arches and shadow of the object on the ground;

iv. colour.

Furthermore, this study had also suggested that the *scenario procedure* was an appropriate procedure to use, in contrast to techniques using open-ended questions. Hence expectations were measured using a refinement of the scenario procedure developed for the earlier trial.

2.1 Materials

Scenarios were designed to have certain features variable, while others were held constant. The variable features were:-

1. Range of target from observer
   - *50-80 m, 200-300 m, 800-1000 m*
2. Target type
   - M113 fire support vehicle (FSV), M113 armoured personnel carrier (APC), Land Rover, 11' x 11' tent, 105 mm howitzer under camouflage net, individual shelter (hootchi);
3. Weather conditions
   - sunny, overcast

The fixed features were:-

1. Object was stationary;
2. Observer was ground based;
3. Observer viewed the target directly, without any optical aids;
4. Targets had no auxiliary camouflage, mobile targets having stopped five minutes earlier.

Two scenarios were repeated at a later date to provide data for test-retest reliability determination. The set of scenarios used is given in Appendix 1.

The 26 scenarios were presented to subjects over three days during the waiting time before they carried out the visual search tasks. Subjects were issued with typed pages carrying 3 scenarios per page (see Appendix 1), and a scale running from "most useful" to "least useful" *for each scenario*. They were also issued with a randomly-ordered set of ten cards each one having one of the cues to detection determined from the early pilot study. Each cue had a letter identifier for ease of specification. The cues are listed below:-

1. Shape of wheels, tracks;

2. Aerials on the targets;

3. Shine from clothing and equipment worn by personnel - e.g. helmets, badges;

4. Differences in patterning of target and background;

5. Overall colour differences between target and its surroundings;

6. Shine from glass surfaces;

7. Shadow of parts of the target near and on the ground - e.g. wheel arch shadows;

8. Bulkiness of the target shape;

9. Mounted guns;

10. Shine from non-glass parts of the target;

It is emphasised that this set of cues was derived from earlier studies on reported causes of detection in which open-ended responses were made [4], as well as a knowledge of military training practice in visual surveillance. Furthermore, common expressions used by soldiers in their reports are embedded in these cues.

Subjects were instructed to imagine the scenario presented, then sort the cards into order of expected usefulness in detecting the target, and, finally, to enter the letter identifier of each card into the appropriate box. Both verbal and written instructions were provided to the subjects, the verbal instructions providing clarification and emphasis, where necessary, of the written instructions. The written instructions are presented in Appendix 2. Subjects were encouraged to work independently when filling in the sheets, and were unhurried in the task.

While the set of scenarios was identical across subjects, there were four different orders used, providing counterbalancing in the presentation order - except for the two reliability checks, which were provided by the pairs 3 and 17, and 6 and 14. For all subjects scenarios 3 and 6 were completed on Day 1, scenario 14 on Day 2, and scenario 17 on Day 3, thus providing one-day and two-day test-retest reliability data.

2.2 Subjects

Subjects were non-commissioned soldiers of 2 Cavalry Regiment of the Australian Army. Of 28 subjects, 22 provided almost complete data on all aspects of the tasks, and all analyses are based on these subjects, or a subset of them as described in the analysis section.

2.3 Results

Data consisted of rank orderings by 22 subjects of 10 cues on each of 26 items. A table giving the mean rank - collapsed across subjects - for each cue on each scenario item is given in Appendix 1 (see Table A.1.1).

Table 2.1 is a summary of the various scenarios in terms of the features which vary between them. Pairs of items differing only in lighting conditions (i.e. sunny versus overcast) are grouped together.

Examination of the variation of cue means shows the following:-

1. Bulk, colour differences, and patterning differences are consistently the major expected causes of detection.

2. Subsidiary expected causes are non-glass shine, guns (for FSV's and APC's), glass shine (for FSV's and APC's), shadow (for tents), and wheel shape and aerials for vehicles.

3. The results for FSV and APC vehicles show a marked difference in the importance of guns - a result consistent with the FSV carrying a 76 mm gun and larger gun turret than the APC with its 20 mm gun.

4. Variations in cue salience between sunny and overcast conditions would be expected to be most marked for glass shine on the vehicular targets. Using the data from scenarios for M113 vehicles a one-sided t-test on mean rankings of cue 6 (glass shine) indicates a difference which is significant at the 0.005 level.

A full comparison of differences between target types, and between obscuration conditions is not possible since not all target types were used in all obscuration conditions, due to anticipated time limitations in test administration. However inspection of the pattern of variation of cues 1,2,7, and 9 for APC's shows that respondents rank cues in a manner consistent with them being aware that heavy ground scrub will lead to a loss of features such as near-ground shadow and wheel arches, with a consequent increase in the salience of features associated with the upper structure of the vehicle.

The above results all provide support for the validity of the procedure as a measure of expected causes of detection. The technique does provide some difficulties for analysis, however, due to the partial inter-dependence of cue rankings. Giving a low ranking to one item forces all other items to have a higher expected level. Hence mean rankings for different items need to be interpreted with care.

TABLE 2.1

Summary of scenarios according to those characteristics which vary between scenarios

Target Type	Target Surround Description	Range (m)	Weather	Item No.
FSV	6-8 m high ti-tree	50-80	Overcast Sunny	1 25
FSV	in heavy ground scrub	800-1000	Overcast Sunny	7 23
FSV	on the brow of a hill	800-1000	Overcast Sunny	11 8
APC	heavy ground scrub (bracken fern etc.)	50-80	Overcast Sunny	9 19
APC	patch of stringybark gum trees	200-300	Overcast Sunny	22 15
APC	light eucalypt forest	200-300	Overcast Sunny	18 26
APC	light eucalypt forest near Cobar	200-300	Sunny	4
APC	heavy ground scrub west of Cobar	800-1000	Sunny	2
Land-Rover	patch of stringybark gum trees	200-300	Overcast Sunny	20 6,14
105 mm howitzer (camouflaged)	open grassland	200-300	Overcast Sunny	24 12
Tent 11'x11'	moderately dense eucalypt regrowth area	50-80	Overcast Sunny	13 10
Tent 11'x11'	patch of stringybark gum trees	200-300	Overcast Sunny	16 21
Hootchi	sparsely treed, heavy bracken	50-80	Overcast Sunny	5 3,17

Reliability data is available for each subject through two pairs of scenarios, (3, 17) and (6,14). These data were used to classify the 22 subjects into two groups - one containing those giving highly reliable responses over the set of scenarios, and the other containing those giving low or poor reliability expectations data. Since some subjects tended to respond with a rather fixed order of expectations and hence gave high inter-item correlations regardless of the particular items being correlated, some measure of whether the obtained correlation is high for that particular subject was needed. Hence the percentile ranking of a correlation in the total set of correlations for that subject was calculated and used as an additional guide in assessing the significance of any correlation coefficient. Table 2.2 presents Spearman rank order correlation coefficients between scenarios 3 and 17, and between 6 and 14 for each subject, together with the percentile ranking of these coefficients for each subject.

TABLE 2.2

Individual subject reliability data derived from scenario pairs (3,17) and (6,14)

Subject	1	2	3	4	5	6	7	8	9	10	11
3 ~ 17	.87	.83	.96	.89	.65	.62	.98	.65	.88	.59	.72
(Perc.)	95	85	95	90	80	70	100	65	80	70	85

Subject	12	13	14	15	16	17	18	19	20	21	22
3 ~ 17	.87	.92	.79	.82	.61	-.02	-.25	.80	.89	.13	.92
(Perc.)	95	90	60	95	75	10	3	45	95	15	95

Subject	1	2	3	4	5	6	7	8	9	10	11
6 ~ 14	.76	**	.83	.76	.01	-.27	.98	.33	.83	.41	-.42
(Perc.)	90	**	85	85	10	5	100	25	70	55	10

Subject	12	13	14	15	16	17	18	19	20	21	22
6 ~ 14	.48	.63	.93	.20	.66	-.14	.41	.82	.68	.82	-.07
(Perc.)	50	75	80	30	70	2	25	55	70	85	5

Subjects 1,2,3,4,7,9,12,13,14,15,16, and 20 were classified as providing satisfactorily reliable expectations data on the basis of the data in Table 2.2. Subject 16, however, had usually only sorted three or four cues into order for each item, and hence his data were rejected. Only data from these subjects - excluding subject 16 - are used in the analysis of how acquisition performance is related to observer expectations.

3. SEARCH PERFORMANCE

The search task involved speeded search for multiple, partially obscured targets in an Australian bushland environment. The task proceeded in two parts - the first being search to detection and localisation, the second being target identification. The experiment took place at Holsworthy near Sydney, and ran over three successive days in October. The weather was sunny with light breeze and light cloud, the final day being slightly cloudier than the previous two. On each day subjects searched from each of three well separated hides, with both targets and hide locations being shifted on completion of a day of observation. Thus subjects searched for an uncertain number of targets of uncertain identity in a realistic environment with which they were generally familiar but did not specifically know.

Each of 22 subjects searched for a total of 30 targets. Table 3.1 summarises the target schedule.

TABLE 3.1

Targets* used at each hide on each day of the experiment.

Day	Hide	Targets			
1	1	LRV	MRV	Tent	
	2	Hootchi	LRV	LR	
	3	LR	Tent	LR	MRV
2	1	MRV	Tent		
	2	MRV	LRV	LR	Hootchi
	3	Tent	LR	LRV	LR
3	1	Hootchi	Hootchi	LR	Tent
	2	MRV	LRV	LRV	
	3	Tent	LR	LR	

* Note that the vehicles identified here as LRV's and MRV's correspond to those denoted in Table 2.1 as APC's and FSV's respectively. The distinction is used systematically throughout this report to assist the reader in disentangling scenario-based information from search-based information. Likewise the terms "cue", and "actual cause" are systematically used with reference to scenarios and actual searches, respectively.

3.1 *Procedure*

Half the subjects carried out the task in the late morning, and the other half in the early to middle afternoon. Search performance was measured by the time to acquisition (at the required level) measured either from the time at which the previous target was found or from the raising of the shutter, whichever was more recent. After the first stage of the acquisition task, subjects were passed a sketch of the search scene and asked to mark, on a transparent overlay of the sketch, where they saw each target, and note the order in which they detected each one. This allowed confirmation of detection and unambiguous assignment of detection times to targets. Following the second stage of the task subjects were asked to specify what target feature or features allowed them to detect the target. This provided information on cue salience.

Subjects commenced their search when a shutter in the hide was opened, this action triggering timing tones which were recorded on audio cassette tape. Subjects held a small metal box with a button-press switch which they depressed on making a detection. They were instructed to continue searching until all targets were found, at which stage the experimenter would release the shutter, closing off the search field. Subjects did not know exactly either how many targets, nor which of the available target types, were in a particular search scene. On completion of the detection stage of search, subjects recorded target locations and order of detection on the scene overlay mentioned earlier. For the identification phase subjects were required to verbally identify the target, and simultaneously depress the timing button, repeating this until all targets previously detected were identified. They were then asked to verbally describe what it was about the target that allowed them to identify it. No constraints were placed on subjects' reports. These were subsequently transcribed and coded into eleven feature categories.

3.2 *Apparatus*

Timing and verbal data were recorded using separate channels of stereo cassette recorders. Button presses were coded as narrow band tones, allowing distinct coding of shutter opening, error correction, and target acquisition occurrences. The coded timing data were subsequently decoded using frequency-tuned switches connected in parallel to each other and fed to the parallel input port of a micro-computer. The micro-computer was programmed to determine time intervals between switch changes to 1 ms precision, and to identify what type of switch change had occurred.

3.3 *Results*

Table 3.2 presents number of detections and median search times for each target.

TABLE 3.2

Summary Data on Detection of Targets by 22 subjects

Target No.	Type	Number of Detections	Median Search Time
1	FSV	21	1.73
3	FSV	20	1.61
15	FSV	21	3.27
4	APC	16	1.95
9	APC	21	2.89
16	APC	22	1.50
17	APC	21	3.13
5	LR	22	1.60
8	LR	22	2.92
10	LR	22	2.01
13	LR	22	1.97
19	LR	20	9.34
20	LR	21	5.88
2	Tent	22	2.53
7	Tent	22	1.73
14	Tent	22	2.00
18	Tent	22	7.70
6	Hootchi	22	1.86
11	Hootchi	21	4.00
12	Hootchi	18	7.40

All search times were unimodal and positively skewed. Appendix 4 gives the corresponding table for the 11 subjects used in the complete analysis.

4. REPORTED CAUSES OF DETECTION

Subjects' open-ended verbal reports of what caused them to detect a particular target were tape recorded and subsequently coded into 11 categories, with the order of report of a particular cause also being noted. Subjects reported up to three causes for any one target. Using a weighting pattern of 4,2,1 for first, second, and third reported cause from a subject, a score was obtained for each cause on each target by summing over all subjects. For each target the weighted sums for the cues were then rank ordered from largest to smallest, this order being used as the measure of feature availability. Table 4.1 gives the reported causes as categorised, while Table 4.2 presents the feature availabilities for each target as calculated by the preceding method.

The choice of weighting pattern is rather arbitrary, though it is reasonable to give greater weight to those causes reported ahead of others. Subsequent analysis of the data using a weighting pattern of 1,1,1 showed no significant differences from those obtained using the 4,2,1 pattern.

TABLE 4.1

Categories of reported causes of detection

Cause Description	Cause Number
Outline	1
Shape Features	2
Glass Shine/Reflections	3
Non-Glass Shine	4
Shadows	5
Guns/Turret	6
Bulkiness	7
Texture/Patterning	8
Markings	9
Shape Lines	10
Colour	11

TABLE 4.2

Order of feature availability for each target determined using a (4,2,1) weighting of the reported causes for detection of that target by each subject

TARGET	ORDER OF FEATURE AVAILABILITY										
MRVs											
1	6	2	1	11	4	7	9	3	8	10	5
3	6	11	7	4	2	1	10	9	8	5	3
15	6	7	11	2	4	1	5	3	10	9	8
LRVs											
4	11	2	8	4	7	6	10	9	5	3	1
9	6	2	11	10	7	1	4	3	5	9	8
16	11	6	1	3	2	7	4	8	10	9	5
17	2	11	6	7	4	10	3	8	1	9	5
LRs											
5	2	11	4	1	10	8	9	7	6	5	3
8	2	11	3	1	5	4	7	10	9	8	6
10	3	2	1	11	5	4	10	9	8	7	6
13	3	2	11	7	4	1	10	9	8	6	5
19	2	3	5	10	9	1	11	8	7	6	4
20	2	3	11	4	9	8	10	1	7	6	5
Tents											
2	1	11	4	7	2	10	8	9	6	5	3
7	2	11	1	7	10	4	9	8	6	5	3
14	7	1	2	11	4	10	9	8	6	5	3
18	11	2	4	10	1	7	8	9	6	5	3
Hootchies											
6	4	2	11	5	1	10	8	3	9	7	6
11	4	11	10	2	8	7	1	9	6	5	3
12	4	1	11	2	10	9	8	7	6	5	3

It should be noted that the causes of detection reported here need not correspond to those under operational conditions. Targets were located with primary consideration given to producing a range of feature and target availability, with only secondary consideration being given to operational validity.

The time delay between a subject's acquisition of a target and his report of what caused that acquisition was kept to minimum, in the belief that the accuracy of such a report would tend to decrease with the length of any delay. No data were collected on the reliability of such reports.

5. CONGRUITY OF FEATURE AVAILABILITY AND SEARCHER'S EXPECTATIONS

Suppose that the expectations of a searcher regarding the usefulness of a particular feature for detection are consistent with the availability of that feature on a target in the search field. Suppose, also, that searcher expectations influence sea ch performance, and that the feature is one of the major causes of detection. Then search time for such a target would be less than if there were a lack of consistency between expectations and availability. It is the hypothesis that search times decrease as the consistency between feature expectations and their availability increases which is examined here. In order to do this, a measure of the consistency (or inconsistency) between an observer's expectations of the usefulness of certain cues and the actual availability of those cues is required. Such a measure is now described.

Let $x(n,t)$ be the cause ranked n for target t (as in Table 4.2).

Let $m[j,x(i,t)]$ be the rank order given by subject j to the expectation of cue i on the set of scenarios classified as representative of target t.

$$\text{Let } I[j,t] = \sum_{k=1}^{N} w(k) * \left| k - m[j,x(k,t)] \right|$$

where $w(k)$ is a weighting term.

Then $I[j,t]$ is a measure of the incongruity (or mismatch) between the availability of a feature on a target, t, and the expectation held by subject j of the usefulness of that feature.

Since most subjects reported no more than three causes of detection it was considered that only three terms should be used in calculating the incongruity measure ($N = 3$). The same weightings (4, 2, 1) were used as in the calculation of rank orders of actual causes of detection (see Table 4.2).

Determination of the incongruity measure requires that a mapping be set up between reported causes and expected cues. Since the reported causes were obtained by a free response procedure, and subsequently categorised independently of the cueing materials, there is not a one-to-one mapping between cues and reported causes. Two cues - Aerials (cue 2), and Shine from personnel clothing (cue 3) - could have no equivalents in reported causes, since targets did not have aerials nor personnel in their vicinity. Table 5.1 specifies the mapping actually used.

TABLE 5.1

The cue corresponding most closely to each cause is listed. The absolute difference in rank order of a cause and its corresponding cue was determined as part of the calculation of an incongruity value

Cause No.	1	2	3	4	5	6	7	8	9	10	11
Cue No.	1	1	6	10	7	9	8	4	4	1	5

6. SEARCH PERFORMANCE AND INCONGRUITY MEASURE

The incongruity measure would have validity only for those subjects who gave reliable scenario data. As noted earlier, 11 of the 22 subjects gave adequately reliable data. Hence the following analyses were carried out only for this subset of subjects. This unfortunately high attrition rate has markedly reduced the power of the experimental procedures.

Search performance dependence on incongruity was examined to see if search time increased with incongruity. For each target, the linear regression of the logarithm of search time on incongruity was found, the logarithm being used because of the positive skewing of search times. Only one target gave a positive correlation significantly different from zero at the 0.05 level on a one-sided test, this being target 7 (an 11' x 11' tent). Such a result is expected by chance, given that 20 targets were examined. Using a two-sided test there was one negative correlation significant at the 0.10 level, again a result attributable to chance. Of the 20 correlation coefficients, 12 were positive and 8 negative, a non-significant difference. Pooling all targets of a given type - APCs, FSVs, Landrovers, tents, and hootchies - no correlations were found to be different from zero at the 0.10 level. Finally, pooling all targets together, a small negative correlation was obtained which was not significantly different from zero. Hence we may conclude that no effect on a subject's search performance has been found which is due to that subject's expectations regarding the causes of detection.

The analysis was also carried out using deviations of individual subject's search times from the mean for that target, so as to compensate somewhat for variations in target difficulty. Again no significant effect was found. A similar null result was obtained when the incongruity measure was determined using an equal weighting of the first five terms.

7. CONCLUSIONS

The results obtained in this study have established that, while there are consistencies in soldiers' expectations for particular target features as determined by a paper-and-pencil test, the expectations so measured do not produce a significant effect on target detection times under field conditions. This conclusion is based on the hypothesis that the extent of agreement between a subject's expectations for specific target features and the actual availability of that feature in any target will differentially affect the subject's search times. No such differential effect was found.

8. DISCUSSION

The limited power of the experiment described here, to detect effects due to a mismatch between what an observer expects to be the major cues to detection, and the availability of such cues, restricts our conclusion to the statement that there is no strong effect of expectations for specific target cues on search performance under these conditions. Factors reducing the power of the experiment are

i. the small number of subjects providing suitable data;

ii. the imperfect matching between reported causes categories, and expected causes categories;

iii. the large variation in search times both between targets and between subjects on a given target;

iv. the interfering effect on search times of prior detections - i.e. search time for other than the first target detected at a given hide would be increased by the decision processes associated with responding to the prior target;

v. the reliance on subjective reports to obtain a measure of feature availability.

All of the above factors can be reduced, except, perhaps (v). Obviously more subjects are required to detect other than very large effects. By providing a list of options - including "other" - for subjects to report the causes of detection (ii) can be improved. The large variation between target detection difficulty can be reduced by appropriate placement - though at the cost of reducing the generalisability of any result obtained. Factor (iv) could be eliminated by restricting the search to only one target per search. To avoid the reliance on subjective reports of feature availability an objective measure of the visibility of selected parts of the target would be required. Such measures are not readily available for field use at present. However, if search scenes were synthesised and displayed on cathode ray display devices, a more objective measure of feature visibility could be derived.

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APPENDIX 1

SCENARIO ITEMS AND SUMMARY OF RESPONSES

TABLE A.1.1

Means and standard deviations of rankings of cues on each scenario item, collapsed across subjects

ITEM NO.	CUE NO.									
	1	2	3	4	5	6	7	8	9	10
1	6.24 (2.45)	5.96 (2.51)	9.28 (1.22)	3.84 (2.31)	4.04 (2.09)	5.76 (2.20)	7.16 (1.93)	2.36 (2.08)	4.56 (2.32)	6.00 (2.87)
2	7.58 (2.20)	5.15 (2.52)	8.08 (1.90)	4.85 (2.26)	3.69 (2.57)	4.38 (2.31)	6.85 (2.35)	2.69 (2.60)	6.15 (2.20)	5.42 (2.54)
3	8.15 (1.54)	8.04 (1.63)	5.81 (1.98)	3.23 (2.10)	2.77 (1.76)	7.19 (1.90)	4.92 (1.88)	4.12 (2.04)	7.77 (1.93)	3.00 (2.43)
4	6.62 (2.32)	6.42 (2.45)	9.08 (1.00)	4.42 (2.45)	4.08 (2.66)	5.79 (2.90)	6.08 (2.14)	2.21 (1.55)	5.21 (2.02)	5.08 (2.81)
5	8.21 (1.44)	7.87 (1.81)	5.50 (1.98)	2.92 (1.96)	1.96 (1.14)	7.83 (1.43)	4.92 (2.02)	4.00 (1.78)	8.04 (1.51)	3.75 (2.11)
6	5.24 (2.55)	5.68 (2.54)	7.96 (1.80)	3.52 (1.84)	3.28 (2.09)	4.88 (2.47)	5.32 (2.26)	4.16 (2.85)	8.52 (2.35)	6.28 (2.58)
7	6.92 (2.43)	5.88 (2.72)	8.68 (1.35)	4.16 (2.38)	3.32 (2.05)	6.28 (2.43)	7.08 (2.15)	2.40 (1.41)	4.64 (2.50)	5.60 (2.47)
8	7.24 (2.05)	4.84 (2.57)	8.56 (1.79)	4.72 (2.34)	4.00 (1.92)	5.72 (2.22)	7.60 (2.04)	2.04 (1.97)	4.32 (2.48)	5.88 (2.44)
9	6.88 (2.78)	4.92 (2.48)	8.80 (1.20)	3.76 (1.77)	3.44 (1.92)	6.92 (1.81)	6.88 (2.60)	2.08 (1.60)	5.16 (2.20)	6.08 (2.42)
10	8.12 (1.31)	7.52 (1.75)	6.88 (1.84)	2.80 (1.67)	3.20 (1.26)	7.20 (2.33)	5.44 (1.94)	1.64 (1.02)	8.16 (1.43)	4.04 (1.89)
11	6.92 (2.64)	5.16 (2.29)	8.76 (1.63)	4.08 (2.21)	4.52 (2.37)	6.56 (2.37)	6.80 (2.40)	1.80 (1.83)	4.08 (1.90)	6.32 (1.97)
12	6.16 (1.91)	7.60 (1.90)	7.40 (2.45)	2.68 (1.41)	3.36 (1.76)	7.60 (1.77)	5.72 (2.22)	2.36 (1.79)	6.28 (2.89)	5.84 (2.74)

ITEM NO.	CUE NO. 1	2	3	4	5	6	7	8	9	10
13	9.08 (1.26)	7.50 (1.73)	6.25 (1.76)	2.79 (0.96)	2.29 (0.84)	7.17 (1.62)	5.71 (1.57)	1.83 (1.40)	8.12 (1.74)	4.25 (1.64)
14	5.12 (2.57)	6.29 (2.05)	8.62 (1.55)	3.79 (2.02)	3.50 (2.63)	4.71 (2.32)	5.83 (1.89)	2.83 (1.84)	8.58 (1.96)	5.71 (2.67)
15	5.62 (2.67)	6.75 (1.88)	8.83 (1.40)	4.62 (2.56)	3.58 (2.58)	5.62 (2.16)	6.71 (2.81)	1.96 (1.17)	5.50 (2.31)	5.79 (2.48)
16	8.67 (1.21)	7.54 (1.76)	6.58 (1.87)	2.50 (1.04)	2.83 (0.80)	7.67 (1.31)	4.92 (1.32)	1.29 (0.61)	8.17 (1.52)	4.83 (1.93)
17	8.58 (1.55)	8.08 (1.11)	5.42 (1.47)	3.00 (1.26)	2.46 (1.19)	7.25 (1.42)	5.33 (2.19)	3.12 (1.92)	8.58 (1.32)	3.17 (2.17)
18	6.24 (2.25)	6.40 (2.08)	8.88 (1.39)	3.12 (1.95)	3.44 (2.14)	6.96 (2.20)	5.92 (2.50)	1.64 (1.13)	6.24 (1.99)	6.12 (2.44)
19	7.84 (1.83)	5.76 (2.52)	8.44 (1.53)	3.60 (2.24)	4.12 (2.29)	5.96 (2.20)	6.88 (2.57)	1.80 (1.06)	5.16 (2.17)	5.44 (2.71)
20	5.62 (2.60)	6.37 (2.38)	8.37 (1.73)	4.79 (1.96)	4.08 (2.33)	3.21 (2.36)	6.25 (2.11)	2.54 (1.68)	8.75 (1.27)	5.00 (2.52)
21	8.71 (1.51)	7.87 (1.54)	6.00 (1.35)	3.04 (1.49)	2.17 (1.07)	7.00 (1.63)	5.50 (1.55)	1.75 (1.01)	8.42 (1.35)	4.54 (2.24)
22	5.21 (2.29)	6.04 (2.09)	8.92 (1.35)	3.62 (1.95)	3.33 (2.30)	7.00 (2.10)	6.83 (2.05)	1.83 (1.46)	5.87 (2.47)	6.33 (2.46)
23	6.79 (2.53)	5.62 (2.53)	8.92 (1.19)	3.67 (2.36)	4.04 (2.17)	6.00 (2.04)	7.62 (1.65)	1.79 (1.32)	4.62 (2.46)	5.92 (2.23)
24	6.29 (2.01)	7.62 (1.80)	7.17 (2.17)	3.37 (2.14)	3.25 (1.56)	8.33 (1.55)	5.25 (2.40)	2.50 (2.24)	4.96 (2.81)	6.25 (2.38)
25	6.46 (2.50)	6.79 (2.36)	9.08 (1.19)	4.46 (2.33)	3.58 (2.20)	5.46 (2.16)	7.17 (2.11)	2.00 (1.26)	4.50 (2.48)	5.50 (2.43)
26	5.83 (2.23)	7.00 (2.22)	8.87 (1.36)	4.50 (2.86)	3.21 (2.12)	5.58 (1.98)	6.75 (2.28)	1.79 (1.29)	5.71 (2.52)	5.75 (2.35)

SORTING RECORD

Name: .... Rank: ....

Squadron: A B Years in Army: ....

Day: Tuesday Wednesday Thursday

Target : An M113 fire support vehicle in amongst 6-8 m high (20') ti-tree, located 50-80 m away. Olive drab, tactical, and stopped 5 minutes ago for a brief stop.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : An M113 armoured personnel carrier in dry, sparsely treed out-back area with heavy ground scrub west of Cobar and located 800-1000 m away. APC is olive drab, tactical, and stopped 5 minutes ago for a brief stop.
Weather : Dry, cool and sunny, 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : Hootchie (shelter, individual) in sparsely treed heavy bracken area located 50-80 m away.
Weather : Dry, cool and sunny, 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

SORTING RECORD

Name: .... Rank: ....

Squadron: A B Years in Army: ....

Day: Tuesday Wednesday Thursday

Target : An M113 armoured personnel carrier among light eucalypt forest near Cobar and located 200-300 m away from observer. Olive drab, tactical, and stopped 5 minutes ago for a brief stop.
Weather : Dry, cool and sunny. 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL **LEAST USEFUL**

Target : Hootchie (shelter, individual) in sparsely treed heavy bracken area located 50-80 m away.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL **LEAST USEFUL**

Target : Land-Rover among a patch of stringy bark gum trees 200-300 m away. Olive drab, stopped 5 minutes ago for a brief stop.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL **LEAST USEFUL**

SORTING RECORD

Name: .... Rank: ....

Squadron: A B Years in Army: ....

Day: Tuesday Wednesday Thursday

Target : An M113 fire support vehicle in amongst 6-8 m high (20') ti-tree, located 80-1000 m away. Olive drab, tactical, and stopped 5 minutes ago for a brief stop.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : An M113 fire support vehicle on the brow of a hill 80-1000 m away. FSV is olive drab, tactical, and stopped 5 minutes ago for a brief stop.
Weather : Dry, cool and sunny, 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : An M113 armoured personnel carrier located among heavy ground scrub (bracken fern etc.) 50-80 m away. Olive drab, tactical, and stopped 5 minutes ago for a brief stop.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

SORTING RECORD

Name: .... Rank: ....

Squadron: A B Years in Army: ....

Day: Tuesday Wednesday Thursday

Target : A tent 11' x 11' in moderately dense young eucalypt regrowth area located 50-80 m away. Olive drab colour, flaps closed.
Weather : Dry, cool and sunny. 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : An M113 fire support vehicle on the brow of a hill 800-1000 m away. FSV is olive drab, tactical, and stopped 5 minutes ago for a brief stop.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : A 105 mm howitzer under a clean camouflage net in open grass land and located 200-300 m away.
Weather : Dry, cool and sunny, 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

SORTING RECORD

Name: .... Rank: ....

Squadron: A B Years in Army: ....

Day: Tuesday Wednesday Thursday

Target : A tent 11' x 11' in moderately dense young eucalypt regrowth area located 50-80 m away. Olive drab colour, flaps closed.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : Land-Rover among a patch of stringy bark gum trees 200-300 m away. Olive drab, stopped 5 minutes ago for a brief stop.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : An M113 armoured personnel carrier located among a patch of stringy bark gum trees 2020-300 m away. Olive drab, tactical, stopped 5 minutes ago for a brief stop.
Weather : Dry, cool and sunny, 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

SORTING RECORD

Name: .... Rank: ....

Squadron: A B Years in Army: ....

Day: Tuesday Wednesday Thursday

Target	:	A tent 11' x 11' among a patch of stringy bark gum trees 200-300 m away. Olive drab colour, flaps closed.
Weather	:	Humid, overcast, 1500 hrs.
Observer	:	Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target	:	Hootchie (shelter, individual) in sparsely treed heavy bracken area located 50-80 m away.
Weather	:	Dry, cool and sunny, 1000 hrs.
Observer	:	Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target	:	M113 armoured personnel carrier among light eucalypt forest, and located 200-300 m away. Olive drab tactical, and stopped five minutes ago for a brief stop.
Weather	:	Humid, overcast, 1500 hrs.
Observer	:	Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

SORTING RECORD

Name: .... Rank: ....

Squadron: A B Years in Army: ....

Day: Tuesday Wednesday Thursday

Target : An M113 armoured personnel carrier located among heavy ground scrub (bracken fern etc.) 50-80 m away. Olive drab, tactical, and stopped 5 minutes ago for a brief stop.
Weather : Dry, cool and sunny. 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : Land-Rover among a patch of stringy bark gum trees 200-300 m away. Olive drab, stopped 5 minutes ago for a brief stop.
Weather : Dry, cool and sunny, 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : A tent 11' x 11' among a patch of stringy bark gum trees 200-300 m away. Olive drab colour, flaps closed.
Weather : Dry, cool and sunny, 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

SORTING RECORD

Name: .... Rank: ....

Squadron: A B Years in Army: ....

Day: Tuesday Wednesday Thursday

Target : An M113 armoured personnel carrier located among a patch of stringy bark gum trees 200-300 m away. Olive drab, tactical, stopped 5 minutes ago for a brief stop.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : An M113 fire support vehicle in heavy ground scrub with very few trees located 800-1000 m away. Olive drab, tactical, and stopped 5 minutes ago for a brief stop.
Weather : Dry, cool and sunny, 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : A 105 mm howitzer under a clean camouflage net in open grass land and located 200-300 m away.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

SORTING RECORD

Name: .... Rank: ....

Squadron: A B Years in Army: ....

Day: Tuesday Wednesday Thursday

Target : An M113 fire support vehicle in amongst 6-8 m high (20') ti-tree, located 50-80 m away. Olive drab, tactical, and stopped 5 minutes ago for a brief stop.
Weather : Humid, overcast, 1500 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

Target : An M113 armoured personnel carrier among light eucalypt forest, and located 200-300 m away. Olive drab tactical, and stopped 5 minutes ago for a brief stop.
Weather : Dry, cool and sunny, 1000 hrs.
Observer : Ground-based, no vision aids.

MOST USEFUL LEAST USEFUL

APPENDIX 2

SORTING TASK INSTRUCTIONS

1. You will be given 10 cards.
   Each card describes some target feature which might be a cue to detection.

2. On the sheet provided are 3 different search situations.
   These situations differ in target, weather, background, and range.

3. Sort the cards into order of usefulness of the feature for detection (i.e. knowing there is a target there, not necessarily what it is). Most useful is put first, least useful last.

4. In the boxes underneath the decription put the circled letters on the cards in order of your sorting - if you put card K as most useful then put K in the leftmost box etc. Put one letter in each box.

5. Shuffle the cards and repeat steps 3 and 4 for the next description.

6. When you've finished return the cards and the sheet to the experimenter.

7. DON'T take any notice of other people's sorting order - there is only one correct way for you to order the cards and no-one else can tell you what it is.

8. Information provided here is confidential, but we need to identify you to relate results here to those in other parts of the investigation. Your name is not coded with the data, nor is the data part of army records.

9. The results from the analysis of this data are intended to assist in camouflage design and training. Results from an earlier investigation in which you assisted are now in draft report form, and have been used to guide the present experiment.

APPENDIX 3

SEARCH INSTRUCTIONS

1. You are to search as rapidly as possible for all the targets in the region you can see. There may be as many as 4 targets or as few as 1 to find.

2. Search as fast as you can to DETECT targets. Press the COUNT button each time you are about 50% sure there is a target where you are looking. Then immediately continue searching for other targets.

3. When you have recorded the correct number of targets the shutter will drop.

4. If, during a search, you wrongly press the COUNT switch you can erase that count by pressing the ERASE switch. You can only erase the most recent count.

5. After the shutter falls you will be asked to indicate on a diagram APPROXIMATELY where each target was, in the order you detected them. DO NOT spend search time accurately locating targets. We only want a rough guide to where you thought something was.

6. Part 2 of the search is for target recognition.

7. The shutter will open, and you will name targets starting from the left-hand side. Do this as fast possible while being at least 95% confident of your identification. Press the COUNT switch as you name the target.

8. The shutter will fall on completion. You then specify what target features allowed you to recognise it.

APPENDIX 4

MEDIAN SEARCH TIMES TO DETECTION FOR ALL TARGETS

TABLE A.4.1

Median detection times for all targets by the 11 subjects used in the full analysis

Target No.	Type	No.of Detections	Median Search Time
1	FSV	11	2.05
3	FSV	11	1.19
15	FSV	10	3.42
4	APC	8	7.39
9	APC	11	4.43
16	APC	11	1.09
17	APC	10	1.61
5	LR	11	2.24
8	LR	11	2.20
10	LR	11	1.90
13	LR	11	1.00
19	LR	9	34.27
20	LR	10	3.57
2	Tent	11	2.53
7	Tent	11	1.53
14	Tent	11	2.00
18	Tent	11	9.64
6	Hootchi	11	1.73
11	Hootchi	10	4.00
12	Hootchi	9	9.75

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