United States Lifeguard Standards Coalition
Evidence Review

On the following pages, you will find a primary question (and in some cases ancillary questions), reviewed by the United States Lifeguard Standards Coalition (USLSC), the draft consensus recommendation of the USLSC, and the Scientific Review Forms (usually two) that detail the specific evidence upon which the consensus recommendation was based.

In most cases, for each question, two independent investigators researched existing evidence, including scientific research and other material, related to the question. Each investigator then completed a Scientific Review Form, listing the evidence and an evidence summary. The level and quality of evidence was rated using a standardized evidence evaluation process. The evidence reviewed included, but was not limited to, the following:

a. Population-based studies
b. Epidemiological studies
c. Case-control studies
d. Historic research
e. Case studies
f. Large observational studies
g. Review of past research summaries, and
h. Extrapolations from existing data collected for other purposes

The scientific reviews were presented to the entire USLSC. Each topic was presented, discussed and critiqued by the assembled experts until consensus was reached.

You are invited to comment on this question (as well as the others) and particularly whether you believe that the evidence adequately supports the consensus recommendation. If you are aware of any additional evidence (e.g. scientific research) that was not considered by the Lifeguard Standards Coalition, please list that evidence in your comments. In any comments you choose to make, please be sure to cite the line number, if you are referring to specific wording of the item.

Before commenting, please review the document in full. This includes an initial document, which contains the question or questions investigated and the consensus recommendation. This is followed, in most cases, by two Scientific Review Forms, which list the evidence that was considered in arriving at the consensus recommendation.

Thank you for your time and consideration in reviewing this question. The deadline for comments is December 12, 2009.

SCANNING TECHNIQUES

Question

What evidence is there to support the effectiveness of scanning techniques in identifying patrons in need of assistance?

Ancillary Questions

- Is there a preferred path for scanning?
- What influences the effectiveness of scanning?

Introduction

Some lifeguard training agencies advocate the use of specific scanning techniques and patterns. However, no direct research has been conducted to support these recommendations.

Evidence Summary

A literature review identified no studies that related to lifeguard scanning techniques. However, some of the gathered information related to distractions and the ability to locate a specific target in a field of targets. Evidence from 25 research studies, with LOE ratings of 3b, 3bE, 2E, 4E, and 5E, does not identify specific and effective scanning techniques to assist in identifying patrons in need of assistance.

Scanning Strategy: People tend to develop their own scanning strategies. However, scanners tend to observe what is in front of them, spending about half the search time on the front of the total viewing area, and less time searching areas to the right and left of the visual field. Experience may have an effect on developing specific scanning patterns, as well as the ability to not dwell on one target too long. Rather than using a rigid scanning pattern, experienced individuals use a flexible scanning strategy that allows them to emphasize important or difficult aspects of a display. Experienced individuals also learn to attend to critical features more efficiently than do individuals with little or no experience. Elliptic scanning may result in less time needed to localize a target. Scan path lengths are shorter than those of matrix, random or diagonal scan paths.

People can scan very quickly. However, the faster the scan is performed, the less is retained in memory.

Target Detection: Sensitivity to a stimulus and reaction times improve with practice. However, although scanning becomes more efficient with practice, it does not become more effective. Regardless, practice does sharpen the observers' ability to recognize targets. Detecting a target becomes more difficult as the scanning environment increases in complexity. For example, scanning may be affected by the number of swimmers in a pool. In addition, the probability of finding a target decreases as the number of locations monitored increases.

If targets have similarities, attention is directed more toward those similarities. Eye fixation on a target is affected by similar targets, ie, finding the target takes longer. If the population is homogenous, search takes longer.

Distractions: It is possible that an increase in incidents or rule violations interrupts scanning.

Increasing the number of distractions decreases search performance.

Also, as the number of children in a pool increases, lifeguards tend to observe the children more than the adults.

Consensus Recommendation

Evidence is insufficient to make a recommendation for or against specific lifeguard scanning techniques.

Standards:

Evidence is insufficient to apply a standard for specific lifeguard scanning techniques.

Guidelines:

Lifeguard certifying agencies and supervisors should provide training programs and in-service protocols that cover the following:

- emphasize scanning all fields within a scanning zone using maximal head movements
- require new lifeguards to practice scanning with supervision and feedback
- emphasize that when populations are similar in appearance, it takes longer to identify potential drowning incidents
- inform lifeguards that distractions greatly affect the scanning process

Options: No recommendations.

Unites States Lifeguarding Standard Coalition
Scientific Review Form

Author: Jerry DeMers	**Organization Representing: YMCA of the USA**
Question: What evidence is there to support the effectiveness of scanning techniques in identifying patrons in need of assistance?	**Date Submitted:** May 20, 2007

Question and Sub-Questions:

This should include the major question originally planned and any changes which occurred during the review process. Please also list any original sub-questions and the changes and those added during the review process.

Original Question:

What evidence is there to support the effectiveness of scanning techniques in identifying patrons in need of assistance.

Subquestions:

a. Is there a preferred path for scanning?
b. What influences scanning effectiveness?

Introduction/Background:

Provide any relevant background on the subject and the need to address this question.

There have been recommendations for scanning techniques which have been implemented by lifeguard training agencies. No direct research has been completed by these agencies that support the recommendations implemented. Lifeguards and supervisors need to understand what, if any, scanning patterns or techniques should be adopted.

Evidence Identification and Review

List the approach to gathering evidence. This should include any electronic databases searched with the terms used and numbers of articles found and reviewed. Also list any reports, prior evidence reviews analyzed and/or position papers evaluated.

Several Data Bases were utilized in the search for the answer to the above question. The following were accessed through the California Polytechnic State University Library.Systems

PolyCat Database
Inter-library loan from the University of Waterloo
Psychological Reports

Perceptual and Motor Skills
Journal of General Psychology
Journal of Experimental Psychology
Research Data Bases
Science Direct Database
Psychological Science
Trends in Cognitive Sciences
Psychology Press
International Journal of Neuroscience
Cognitive Psychology
ACM Digital Library
ACM Digital Library Portal California State University
Defense Technical Information Center
Journal of Sports Sciences
Academic Radiology
Nature

Summary of Key Articles/Literature/Reports/Data Found and Level of Evidence

(Please fill in the following table for articles that were used to create your recommendations and/or guidelines)

Author(s) and Year published	Full reference	Summary of Article (if abstract available, first paste abstract and then provide your summary	Level of Evidence (Using table below)
Colvin, K., Dodhia, R. & Dismukes, R.	Is Pilots' visual scanning adequate to avoid mid-air collisions? International Symposium on Aviation Psychology, Columbus, OH: The Ohio State University 2001.	Twelve pilots were involved in this study. Eye tracking data were collected. Participants were given written instructions that emphasized that they were to perform all tasks in a simulator, including scanning for traffic, just as they would in actual flight. Participants flew an experimental scenario. Participants spent just under one third of their time looking outside the cockpit, except during the traffic period, in which looking outside increased 51%. However when traffic ceased, the percentage of time looking outside again dropped. On average participants fixed on the instrument panel far more frequently than the windscreens, and they fixated the center-front windscreen far more frequently than the other three windscreens. Scanning the off-center windscreens was much less adequate.	Level 3bE
Kasarskis, P., Stehwien, J., Hickox, J., Aretz, A.	Comparison of Expert and novice scan behaviors during VFR flight. (2001). International Symposium on Aviation Psychology, Columbus, OH: The Ohio State University	Abstract: Seven expert and ten novice pilots flew several simulated approaches and landings while their scanning behavior was recorded. We found that experts had significantly shorter dwells, more total fixations, more aimpoint and airspeed fixations and fewer altimeter fixations than novices. Experts were also found to have better defined eye-scanning patterns. Pilots also had more total fixations and shorter dwells on trials with more precise landing, regardless of expertise. DeMers Summary: The questions	Level 3bE

		examined in this experiment were (a) to what extent are the various sources of information visually sampled during effective landings, including flight instruments and the visual world as seen through the windshield, and (b) what are the differences in these scanning strategies between novices and experts? Ten novice and six expert pilots participated in the study. Novice pilots had logged between 40-70 hours of VFR flight time, with an average of 46.8. Expert pilots had logged between 1500 – 2150 hours of flight time, with an average of 1980 hours. An eye and head tracker was utilized to track head and eye movement. Each participant performed 15 landing trials. They were then evaluated on their ability to land on the runway and their scanning behavior was recorded. Results: Experts had more total fixations on instruments than novices during the landing process. Expert pilots transitioned between sighting the runway and instruments than more often than novice pilots. Expert pilots revealed a stronger and more defined scan pattern than novice pilots. This type of active scan pattern corresponds to better maintenance of airspeed and better landing performance. The more active the eyes, in a consistent, efficient pattern, the better a pilot performs.	
DeMaio, J., Parkinson, S., Leshowitz, B., Crosby, J. & Thorpe, J.	Visual Scanning: Comparisons between student and instructor pilots. Defense Technical Information Center, Abstract 1976	Abstract: Total manuscript not available. The performance of instructor pilots and students pilots was compared in two visual scanning tasks. In the first task both groups were shown slides of T-37 instrument displays. Some slides contained a significant deviation from a pre-determined straight and level course, and the task was to detect the error as quickly as possible. Instructor pilots detected errors faster and with greater accuracy than student pilots, this providing evidence for the validity of the procedures employed. However, contrary	Level 3bE Abstract only

		to the concept of a fixed cross-check, student pilots showed a greater tendency to employ a systematic search pattern than did instructor pilots. This result suggests that rather than using a rigid scanning pattern, instructor pilots, by virtue of their additional flight experience, use a flexible scanning strategy which allows them to emphasize important or difficult aspects of the display. In the second experiment the attention diagnostic method task was employed to determine if the experience in visual scanning obtained in the flight situation would transfer to a novel scanning task. In the first session there were no differences in response latency between instructor pilots, students pilots, and a group of university students. Instructor pilots, however, showed a significant linear decrease in latency over the course of eight sessions while this trend was absent in the other two groups. This suggests that instructor pilots learn to attend to critical features more efficiently than do individuals with little or no flight experience. The results of the present experiments recommend the use of a variety of scanning tasks in the UPT program to facilitate the more rapid development of adaptive scanning strategies.	
Findlay, J	Eye scanning and visual search. Department of Psychology, University of Durham South road, Durham, DH!, 3LE	Abstract: During visual search a number of processes operate to direct the eyes efficiently to the search target. Our understanding of these processes has advanced considerably in the last ten years and this chapter gives a perspective about how the eyes are controlled during search activity. During each fixation, visual information is analyzed in a way that emphasizes the central part of the visual field. This analysis proceeds in parallel on the basis of an internal salience map, which develops over time. The point of highest salience is selected as the saccade destination. There is no	Level 5E

		convincing evidence supporting serial scanning by covert attentional processes within a normal fixation during free viewing. However, the analysis may be assisted by information gained during the preceding fixation through the process of non-foveal preview. If the analysis is adequate to locate the search target, the eyes are moved to it, otherwise a new fixation location is selected. Particularly with large search displays, more strategic processes are also important that distribute fixations over the area to be searched.	
McCarley, J, Kramer, A., Wickens, C., Vidoni, E. & Boot, W.	Visual skills in airport-security screening. Psychological Science. 2004	Abstract: An experiment examined visual performance in a simulated luggage-screening task. Observers participated in five sessions of a task requiring them to search for knives hidden in x-ray images of cluttered bags. Sensitivity and response times improved reliably as a result of practice. Eye movement data revealed that sensitivity increases were produced entirely by changes in observers' ability to recognize target objects, and not by changes in the effectiveness of visual scanning. Moreover, recognition skills were in part stimulus-specific, such that performance was degraded by the introduction of unfamiliar target objects. DeMers Summary: Sixteen young adults searched stimulus images for the presence of a knife. Across several days, each observer completed five experimental sessions of 60 target-present trials and 240 target-absent trials each. Sensitivity and reaction times improved with practice. Observers were faster to fixate the target region of an image, and were both faster and more likely to recognize the target once they had fixated on or near it. Subjects were quicker to fixate the target region of an image as a result of practice, but were not more likely to do so. In other words, scanning became more	Level 4E

		efficient with practice but not more effective. Scanning efficiency was reduced when unfamiliar target shapes were introduced following practice, whereas effectiveness was not. Practice did indicate that practice did sharpen observers' ability to recognize targets.	
Horrey, W., Wickens, C., & Consalus, K.	Modeling drivers' visual attention allocation while interacting with in-vehicle technologies. Journal of Experimental Psychology: Applied (2006)	Abstract: In 2 experiments, the authors examined how characteristics of a simulated traffic environment and in-vehicle tasks impact driver performance and visual scanning and the extent to which a computational model of visual attention could predict scanning behavior. In Experiment 1, the authors manipulated task-relevant information bandwidth and task priority. In Experiment 2, the authors examined task bandwidth and complexity, while introducing infrequent traffic hazards. Overall, task priority had a significant impact on scanning; however, the impact of increasing bandwidth was varied, depending on whether the relevant task was supported by focal (e.g., in-vehicle tasks; increased scanning) or ambient vision (e.g. lane keeping; no increase in scanning). The computational model accounted for approximately 95% of the variance in scanning across both experiments. DeMers Summary: For both experiments, task value, here a proxy for area of interest was the strongest predictor of scanning behavior. For tasks that had a high associated value, drivers tended to scan to the appropriate area more frequently, at the expense of other areas. Basically, the more instrumentation in an automobile, the less the area is scanned.	Level 4E
Blackwell, J., Simmons, R, & Watson, J.	Preliminary study on scanning techniques use by U.S. Coast Guard lookouts	Only Abstract Available: This research was a cooperative study undertaken by the US Coast Guard	

	during search and rescue missions Defense Techinical Information Center Access Number: ADA12597, August 1982.	Research and Development Center (USCG R&D) and the US Army Aeromedical Research Laboratory (USAARL). Eye performance data were collected from Coast Guard personnel performing as lookouts during simulated search and rescue missions on HH-3F helicopters, a 210-foot cutter, and an 82-foot cutter. Visual performance was measured by means of NAC Eye Mark Recorder systems during the Winter 1981 Visual Detection Experiment conducted by the USCG R&D Center in the Gulf of Mexico off of Panama City, Florida, during January and February, 1981. The visual performance measures were analyzed to determine the scanning patterns utilized by the various lookouts. Based upon this initial study, it appears that most personnel spend about one half of search time on only one segment of their total assigned viewing area. For example, pilots and copilots spend most of their time looking out their respective front windows. For the surface vessels, the subjects seemed to display the condition termed eye lock -- that is, a lookout would position his eyes and keep them stationary, allowing the movement of the search vessel to dictate his scan path. The scanner patterns prescribed in the US Coast Guard training manuals were used infrequently; rather the observers followed the outline of structures within their fields of view.	
Croft, J., Pittman, D. & Scialfa, C.	Gaze behavior of spotters during an air-to-ground search. Eye tracking research and application: Proceedings for the 2006 symposium on Eye tracking research & applications	Abstract: Crashed aircraft must be located quickly to minimize loss of life, often requiring visual search from the air. This study was designed to develop methods for evaluating the gaze behaviors of spotters during air-to-ground search and to compare field derived measures with similar lab measures reported in the literature. A secondary aim was to assess adherence to a prescribed scan path,	Level 2E

	ACM Press, New York	evaluate search effectiveness, and determine the predictors of task success. Eye movements were measured in 10 volunteer spotters while searching from the air for ground targets. Static visual acuity at several eccentricities and contrast levels and performance on a lab-based search performance were also measured. Gaze relative to the head was transformed to gaze relative to the ground using information from the scene. Coverage and task success were similar to literature values from a lab-based study of air-to-ground search. Air search task success could be predicted best from a combination of gaze and laboratory variables and, like previous lab-based research, experience was not one of them. Results from this field study provide some support for the generalizability of lab research. In both lab and field research performance is quite poor. Future improvements in air search and rescue success will depend upon improvements in training, the refinement of scan tactics, changes to the task methods or environment, or modifications to parameters of the search exercise. DeMers Summary: Ten spotters volunteered to participate. Mean age was 37.1 yrs. A head-mounted gaze tracker recorded spotters' gaze during the task. The task was designed to replicate an actual airborne search, using a grid over mixed foothills terrain. Despite the fact that all spotters were trained to use a specific and systematic scan technique, they found no evidence that they followed their eye movements followed this prescribed. The data indicate that hit rates are rather poor, that the estimated visual coverage of the environment is low and that experience does not predict either environmental	

		coverage or task success.	
Seagull, F. & Gopher, D.	Training head movement in visual scanning: A embeddedd approach to the development of piloting skills with helmet-mounted displays Journal of Experimental Psychology: Applied, 1997, Vol 3, No. 3, 163-180	Abstract: Pilots using a single-eye helmet mounted display (HMD) for night vision have orientation problems that are strongly affected by head movement. However, it is precisely this behavior that is called upon to expand the limited field of view. The reported experiment trained pilots to use head movement in visual scanning. Participants piloted a simulated helicopter using either a single-eye HMD or a binocular through-the-window display. In training, participants piloted HMD flights while carrying out a secondary task that required systematic head movement. Results show that trained groups performed considerably better than control groups in subsequent HMD test flights. These groups learned to increase their head movement, whereas control groups spontaneously reduced theirs. Relatively short but directed training was hence highly effective in reshaping basic scanning behavior and improving performance in a complex, dynamic visual environment. DeMers Summary: Twenty-five male students were recruited through a campus advertisement. Ages ranged between 19-26 years. Subjects had no previous flight experience. Each was randomly assigned to one of the five experimental groups. Participants flew a simulated H-19 helicopter through a computer-generated canyon during trials of a maximum of 4 min. each. Five experimental groups of 5 individuals each were exposed to different training paradigms during the training phase. The experimental results support the claim that a training procedure based on a systematic requirement to perform head movements within the HMD environment	Level 2E

		may improve the general ability of trainees to use this system in flight. Taken together, the two groups that experienced the target-capturing task involving head movement had a larger number of completed flights, longer flight durations in incomplete flights, and a higher rate of improvement with training. In contrast, with practice the three control groups reduced their head movement during HMD flights, whereas no change was observed in their head movement under normal flight conditions. Training head movement improves range of scanning.	
Scharroo, J, Stalmeirer, P. & Boselie, F.	Visual Search and Segregation as a function of display complexity. The Journal of General Psychology, 2001, 121 (1) 5-8.	Abstract: Complexity is proposed as an important psychological factor in search and segregation tasks. Displays were presented with target and non-target areas that were each built up of one type of randomly rotated micropatterns. We manipulated experimentally (a) the complexity of the target elements, as measured by Garner's (1970) invariance criterion; (b) the complexity of the target region; (c) the complexity of the nontargets; and (d) the number of elements within a target region. The main result is that detectability increases when the within-region complexity of the target and the nontarget regions decreases. Furthermore, interactions between the target and nontarget areas affect detectability too: We found that search asymmetry is produced by the asymmetry is produced by the asymmetrical effect of complexity when target and nontarget areas are interchanged. DeMers Summary: Twenty-four subjects participated in this experiment. All had normal vision. Stimuli were presented on a video monitor. Each stimulus display was produced by placing 81 micropatterns at the intersections of a 9" x 9" square lattice. The micropattern was randomly	Level 2E

		displaced with the restrictions that patterns did not touch each other and that the distance between neighboring patterns was not larger than the pattern size. The micropatterns were randomly rotated. Nine different micropatterns, representing three levels of complexity, were used to compose the stimulus displays. The subject's task was to decide by forced choice which quadrant of the display contained the target. The complexity of a single micropattern is inversely proportional to the amount of rotational and translational symmetry of the micropattern. If the micropatterns are randomly rotated and displaced, then irregularities arise when the patterns are highly complex. These irregularities introduce additional distractions. **Detectability will therefore become more difficult as complexity increases.**	
Harrell, W. & Boisvert, J.	An information theory analysis of duration of lifeguards scanning. Perceptual Motor Skills, 2003, 97, 129-134.	Abstract: Observers recorded the duration of scanning by six lifeguards in three indoor swimming pools. Duration of scanning was significantly predicted by the absolute numbers of child swimmers (<17 years) in the pools and when numbers of child swimmers were represented in terms of bits of information. Duration of scanning increased as a linear function of both numbers of children and child bits of information. These results are interpreted in terms of the Hick-Hyman law of information theory. Lifeguards appear to simplify the task of information processing and decision-making by concentrating on children as a more at-risk group of swimmers. Duration of scanning was not significantly related to changes in number of adult swimmers. DeMers Summary: Subjects were 6 lifeguards , aged 19-22 years. Lifeguards we observed with no effort made to	Level 3b

		interview them. Each lifeguard was observed 12 times over a 60-min. period. For every 5-min. segment of the 60 min., the first 3 min. was spent noting whether the lifeguard was looking at the areas of the pool containing swimmers and the length of time (duration of scanning). During the remaining 2 min. of each 5-min. segment, observers counted the number of children (1-17 years) and adults (>17 years) in the pool. As the number of children in a pool increases, so does their informational value. Lifeguards, correspondingly, increase time taken to scan the pool and process information about these children, These findings suggest that lifeguards tend to assume that adults are "safer," in the sense that they con look after themselves or have the swimming skills to avoid jeopardy. Lifeguards essentially simplify information gathering and processing tasks by concentrating their watchfulness on children.	
Harrell, A.	Lifeguards' vigilance: effects of child-adult ration and lifeguard positioning on scanning by lifeguards. Psychological Reports, 1999, 84, 193-197	Abstract: Observers recorded visual scanning by four at three indoor public swimming pools. Scanning increased as a positive function of the ratio of children to adult swimmers, i.e., scanning was greater when the ration was high, suggesting that lifeguards became more concerned about the risks to children and the ability of nearby adult swimmers to monitor these children when the number of children significantly exceeded the number of adults. Absolute numbers of children, however, decreased number of scans, possibly because of greater number of incidents and rule violations requiring lifeguards' attention which compete with watching the pool. Lifeguards were more likely to scan a pool area when they were in elevated towers versus standing on the pool decks. Lifeguards' scanning declined later in the day, possibly due to	Level 3b

		fatigue or because of competing activities of pool maintenance. DeMers Summary: Four lifeguards, aged 21 to 25 years, observed at three different indoor public swimming pools from 1:25 p.m. to 5:30 p.m. on one day of observation. Each lifeguard was observed 12 times over a 60 min. period. As the child-adult ratio increased, so did the number of lifeguard scans. It is believed that this represents a tendency for lifeguards to delegate vigilance to adults who are in the pool at the same time as children. Vigilance by lifeguards increase, however, as children significantly exceeded the number of adult swimmers, presumably because the delegation of vigilance becomes more difficult and problematic for the untrained adults. As the absolute number of children increased, lifeguard scans declined.	
Sireteanu, R. & Rettenbach, R.	Perceptual learning in visual search generalizes over tasks locations, and eyes. Vision Research, 40 (2000) 2925-2949.	Abstract: In a visual search task, targets containing elementary features are detected in parallel, while a serial search is necessary for the detection of a target without a feature, or for target containing conjunctions of features. In this study, we reinvestigated the role of practice in visual search tasks, using an uncued visual search paradigm. Under some circumstances, initially serial tasks can become parallel with practice. Perceptual learning a feature search tasks is rapid (a few hundreds of trials are sufficient to transform serial into parallel search), long-lasting (a learned task is retained over several months), but far less specific than learning of other visual tasks. Learning transfers from one task to another, from one location in the visual field to another, and between the two eyes of a given subject, even if the subject has reduced stereopsis. Search for a conjunction of orientation and colour	Level 2E

		becomes more efficient, suggesting that a different search strategy emerges after prolonged practice. These results suggest that learning o visual search tasks modifies neural structures located at a high level in the visual pathway, involving different, presumably more central neural circuits, than the learning of visual discriminations and hyperacuity. DeMers Summary: The lack of specificity of learning of visual search tasks suggests that what happens is not an improvement in the perception of a particular feature; rather, it seems that we are witnessing an improvement in search strategy.	
Davis, E., Shikano, T, Peterson, S., & Michel, R.	Divided attention and visual search for simp versus complex features. Vision Research, 43 (2003), 2213-2232.	Abstract: Under what search conditions does attention affect perceptual processes, resulting in capacity limitations, rather than affecting noisy decision-making processes? Does parallel or serial processing cause the capacity limitations? To address these issues, we varied stimulus complexity, set size, and whether distractors were mirror images of the target. Both target detection and localization produced similar patterns of results. Capacity limitations only occurred for complex stimuli used in Within-object conjunction searches. Parallel processing, rather than serial processing, probably caused these capacity limitations. Moreover, although mirror-image symmetry adversely affected early visual processing, it did not place additional demands on attention. DeMers Summary: In the case of simple feature search, when the target had a critical feature (gap) or unique categorical attribute that distinguished it from all distractors, target location was easier. Increasing the number of distractors hurt search performance.	Level 2E

Verghese, P. & McKee, S.	Visual search in clutter. Vision Research, Science Direct, December, 2003	Abstract: Detecting a target in clutter is particularly difficult because the observer must monitor many potential locations to find the target, and because the clutter itself might mask the target. To investigate whether contemporary models of search can account for visual search in clutter, we measured the detections of an oblique string of five aligned dots presented at an unknown location as a function of noise density. Observers judged which of two 200 ms intervals contained the signal string. At a give density, noise composed of oriented pairs of dots greatly degraded detection compared to random dot noise, especially if the paired noise shared the same orientation as the signal. Increasing the orientation difference between the paired noise and the signal improved detection, as did increasing signal length. We successfully modeled these results with an array of multi-scaled oriented detectors optimally tuned for the signal string. These results indicate that search for these simple patterns in noise is based on competing responses in oriented filters. DeMers Summary: This study shows that the probability of finding the target decreases as the number of locations monitored increases. Search performance is largely captured by a decision process acting on the output of oriented detectors. Search is affected by competing responses (If things look the same or similar, search takes longer).	Level 3bE
Findlay, J., Brown, V. & Gilchrist, I.	Saccade target selection in visual search: the effect of information from the previous fixation. Vision Research 41 (2001) 87-95	Abstract: This paper reports an analysis of saccades made during a task of visual search for a colour shape conjunction. The analysis concentrates on the saccade following the first saccade, thus complementing an earlier paper where the first saccades were analysed. The further analysis addresses the issue of what information might be held in trans-	Level 3bE

	Saccade: eye movement	saccade memory. As with the first saccade, incorrect second saccades tend to fall on distractors sharing one feature with the target. The proximity of the target to the fixation location immediately prior to the saccade is a very significant determinant of whether the saccade will reach the target. The results lead to the conclusion that in the majority of cases, choice of saccade destination is made afresh during each fixation with no carry-over from the previous fixation. However, in a small number of cases, second saccades are made after extremely brief fixation intervals. Although these saccades show a similar probability of reaching the target as those following longer fixations, it is argued that this sub-set of saccades are pre-programmed at the time of the preceding saccade. DeMers Summary: The task was to move the eyes to a pre-defined colour-shape conjunction target. One target was present on each trial, occurring with equal probability in each of the 16 display locations. The displays were presented for 1 sec., and with very rare exceptions, the eyes reached the target within this time. This study utilized two targets. The first saccade analysis showed that erroneous first saccades did not land at random on non-target elements. They were more likely to land on distractors sharing one feature with the target and less likely to land on distractors not sharing a common feature with the target. There is a clear tendency for erroneous second saccades to be directed to an item sharing a target feature although the tendency is less marked than with the first saccades. It was evident that target proximity prior to the second saccade, i.e. during fixation 2, strongly determines the likelihood of	

		this saccade reaching the target. Implications: Eye fixation on a target is affected by similar targets. It takes longer to find the target.	
Bahcall, D. & Kowler, E.	The control of saccadic adaptation: implications for the scanning of natural visual scenes. Vision Research. 40. 2000 2779-2796 .	Abstract: Accurate scanning of natural scenes depends on (1 attentional selection of the target; (2) spatial pooling over the attended target to compute the precise landing position; and (3) adaptive modification of saccades to ensure saccadic accuracy. The present experiments studied adaptation. Adaptive modifications were induced by displacing the target during saccades. Adaptation was found to be: (1) similar for a small target point and a large target circle, despite the differences in the spatial pattern of landing position errors for each; (2)unaffected by instructions to look part way to the target, even though such instructions altered landing position error relative to the target; and (3) insensitive to symbolic cues disclosing the direction of the intra-saccadic displacement. Briefly delaying the presentation of the post-saccadic target greatly reduced adaptation. Neither corrective saccades, nor the position errors that trigger corrections, were involved in adaptation because corrective saccades rarely occurred with a large target circle even though the circle produced as much adaptation as the single point. Taken together, the results do not support the traditional notion that post-saccadic retinal position error controls adaptation. We propose that adaptation relies on a comparison of the actual post-saccadic retinal image with the post-saccadic image that would be predicted based on a representation of the planned saccade. Such a comparison: (1) is consistent with our results; (2) may be more effective than retinal position error in controlling adaptation in natural visual scenes containing large targets and	Level 3bE

		backgrounds; and (3) is similar to the motion-based adaptive mechanisms associated with the VOR. Similarity between the adaptive control of saccades and adaptive control of the VOR raises the possibility that the most important role of saccade adaptation may be the coordination of eye and head movements during shifts of gaze. DeMers Summary: Saccadic eye movements are crucial for the performance of visual tasks. They bring selected objects to the fovea, providing a sequence of high-resolution views of the most informative sections of the scene. Two characteristics of natural scenes pose challenges to achieving effective saccadic control. First, the selected targets are usually surrounded by extraneous visual backgrounds. For saccades to be accurate, the influence of the backgrounds must be reduced or eliminated, and the saccadic programs based on the targets alone.	
Araujo, C., Kowler, E. & Pavel, M.	Eye movements during visual search: the costs of choosing the optimal path. Vision Research 41 (2001) 3613-3625.	Abstract: Saccadic eye movements are usually assumed to be directed to locations containing important or useful information, but such assumptions fail to take into account that planning saccades to such locations might be too costly in terms of effort or attention required. To investigate costs of saccadic planning, subjects searched for a target letter that was contained in either one of two clusters located on either side of a central fixation target. A target was present on each trial and was more likely to appear in one cluster than the other. Probabilities were disclosed by differences in cluster intensities. The distance between each cluster and central fixation varied. The presentation time was limited (500 ms) to ensure that a successful search would require a wisely chosen saccadic plan. The best chance of finding the target would be to direct the first saccade to the	Level 3bE

		high-probability location, but only one of the six subjects tested followed this strategy consistently. The rest preferred to aim the first saccade to the closer location, often followed by an attempted search of the remaining location. Two-location searches were unsuccessful; performance at both locations was poor due to insufficient time. Preferences for such ineffective strategies were surprising. They suggest that saccadic plans were influenced by attempts to minimize the cognitive and attentional load attached to planning and to maximize the number of new foveal views that can be acquired in a limited period of time. These strategies, though disastrous in our task, may be crucial in natural scanning, when many cognitive operations are performed at once, and the risk attached to a few errant glances at unimportant places is small. DeMers Summary: Making a successful search is contingent on the appropriate saccadic planning. A successful search depended on the direction of the first saccade. All subjects scored better than 80% correct when the first saccade was made to the cluster that contained the target and less than about 30% correct when the first saccade was made in the opposite direction. This outcome confirms that the best strategy to ensure the highest proportion of correct reports is to use the probability cue to direct the first saccade to the cluster most likely to contain the target.	
Findlay, J. & Brown, V.	Eye scanning of multi-element display 1. Scanpath planning. Science Direct, Vision Research 46, 2006, 179-195/	Abstract: We recorded oculomotor scanpaths in a task that required individuals to scan through displays consisting of a small number (between 3 and 12) of near-identical items. The task required each item to be fixated at least once and our objective was to explore the principles governing the generation of scanpaths. In general the observers	Level 3bE

		carried out the task efficiently, although omissions occurred quite frequently (about 25% of trials) in the 12-itme case. Backtracking occurred rarely except in the case of immediate rescanning back to the previously fixated item. Such immediate backtracking occurred on about 4% of fixations and, in contrast to more distant backtracking, was not associated with increased errors. Evidence was found for both direction scanning strategies and scanning strategies based on the global external contour. DeMers Summary: Displays were generated by a computer. Each display had two rings located in fixed positions, a red ring in the top left corner and a blue ring in the bottom right corner. The red ring contained a target letter and the blue ring a numeral. A set of black rings, each containing a letter, were allotted locations chosen at random from within the square display, with the constraint that the separation between all ring centers was at least 2.8 deg. The task was to scan the black rings, noting the number of occasions that the enclosed letter matched the test letter provided in the red ring. On 50% of the trials this number matched the comparison numeral Nb thus requiring a Yes response to be made on a response keybox. On the remaining trials a No response was required. The subjects were instructed to look first at the red ring on the top left, then to look through the black rings and finally to look at the blue ring. The subjects' responses were generally correct although with occasional errors. Unsurprisingly, errors in general increased with the number of rings to be scanned. Other analyses show the power of the proximity effect. This effect is the tendency for saccades to be directed to the closest target to the current fixation point.	

		Subjects tended to develop their own scanning strategies. Subjects appear to use a scanning strategy that is not based on direction selection in any straightforward way. It was noted that a systematic scan through a randomly arranged set of items might plausibly be carried out in a number of different ways. In this study, subjects used several different strategies.	
Saarinen, J. & Julesz, B.	The speed of attentional shifts in the visual field. Procedures for the National Academy of Science. Vol. 88, pp 1812-1814, March 1991.	Abstract: The scanning speed of focal visual attention was measured directly by flashing a sequence of two, three, or four numerals one by one at random retinal positions and at distance from each other to avoid interference between the numerals. Each numeral was followed by a mask pattern so the observers had to move their focal attention inn the visual field in synchrony and at the same speed as the presentation rate of the numerals in order to recognize every numeral in the stimulus sequence. Observers could recognize the numerals orders of magnitude above the theoretical chance level of performance even when the presentation rate was as fast as 33 ms per numeral. However, the temporal order of the numerals was perceived rather poorly at the fast presentation rates and for the sequences of four numerals. DeMers Summary: Speed of focal visual attention can be quite fast. Observers lost information about the order of the numerals in the sequence even though they could still recognize the numerals. Practical application—the faster you scan the less you retain in memory.	Level 3bE
Simonin, J., Kieffer, S. & Carbonell, N.	Effects of display layout on gaze activity during visual search.	Abstract: We report an experimental study that aims at investigating the influence of spatial layout on visual search efficiency and comfort. 4 layouts were used for displaying 120 scenes comprising 30 realistic colour photos	Level 3bE

	Science Direct Data Base, 2006.	each: random, elliptic, radial and matrix-like. Scenes (30 per structure) were presented to 5 participants who had to select a pre-viewed photo in each scene using the mouse. Eye-tracking dat indicate that elliptic layouts provided better visual comfort than any of the other layouts (shortest scan paths), and proved to be more efficient than matrix layouts (shorter search times). The results were statistically significant. DeMers Summary: Five experienced computer users with ages between 24 and 29 and normal sight carried out 120 visual search tasks in scenes displayed on a 21" screen. Each scene included 30 realistic colour photos arranged along four different symmetrical structures. 1): Matrix-like (2D array), Elliptic (two concentric ellipses), Radial (eight radii along medians and diagonals of the screen),, and Random. For each scene, participants had to locate a pre-viewed photo in the scene, and to select it as fast as they could using the mouse. Target localization time is significantly shorter for Elliptic layouts then for Matrix layouts. In addition, scan path length is significantly smaller for Elliptic layouts compared to the three other structures.	
Wolfe, J. **Serial**: attention is deployed to one item (or a group of items) at a time. **Parallel**: processing many items at once.	Moving towards solutions to some enduring controversie in visual search. TRENDS in Cognitive Sciences, Vol. 7, No. 2, Feb. 2003.	This article addressed questions rather than answers. There was a discussion relating to which method might be more effective	Level 5E
McCarley, J., Vais, M., Pringle, H., Kramer, A., Irwin,	Conversation Disrupts Visual Scanning of Traffic	An experiment asked younger (M= 21.43 yrs.) and older (M=68.43 yrs) observers to perform a change detection task using	Level 3bE

D., & Strayer, D.	Scenes. Cal Poly Data-base, Beckman Institute, University of Illinois at Urbana-Champaign, U.S. Air Force Academy, University of Utah. No date available	real-world traffic scenes, either while concurrently maintaining a conversation, or under single-task control conditions. Results demonstrate that even simple conversation can disrupt attentive scanning and representation of a visual scene. Error rates for change detections were higher during conversation than under single-task conditions, and larger numbers of saccades were necessary to locate and respond to the changing item. Additionally, fixation durations were reduced under dual-task conditions, suggesting that detrimental effects of conversation on performance may have, at least in part, been the result of abbreviated time available for perceptual analysis and saccade planning. An increased number of saccades were necessary for change detection in dual-task conditions suggesting that one effect of conversation was to impair peripheral guidance of attention toward the target.	
Lavine, R., Sibert, J., Gokturk, M., & Dickens, B.	Eye-tracking measure and human performance in a vigilance task. Aviation, Space, and Environmental Medicine, Vol 73(4), Apr. 2002. pp. 367-37 EBSCO Research Database PsycINFO Database Record.	Only Abstract available: Visual scanning is necessary for aviation safety and similar vigilance tasks, but little is known about its characteristics in such tasks, including possible changes with alertness and fatigue. The authors explored concurrent eye movements and human performance during a vigilance task designed to require frequent visual scanning. Effects of time and auditory stimuli were examined. A corneal-reflectance, PC-based system provided eye movement measures. Stimuli were 4 digits in a rectangular array, changed at an event rate of 4 sec. for a task duration of 30 min. 20 subjects (20-54 yrs) were asked to respond to specific, infrequent signal arrays by bar press,, under both 50 dBA white noise and 90 dBA intermittent and unpredictable sound-burst conditions	Level 3bE

		(SBC), counterbalanced for order. With time-on-task, subjective fatigue ratings increased, dwell time defined as the total duration of fixations on target digits decreased, number of fixations decreased, and fixations were further from target digits in both conditions. Fixation durations did not change significantly with time or condition. Off-target visual scan-paths were less frequently followed by hits than were on-target scan- paths in both conditions. With the SBC, fixations were closer to target digits and hit rates increased.	
Verghese, P.	Visual search and attention: a signal detection theory approach. Neuron, Vol. 31, 523-535, August 30, 2001.	Review of Literature: Visual attention has been implicated in searching for targets among distractors, but it is only recently that converging evidence from physiology and psychophsyics has clarified the mechanisms by which attention influences search. Attention acts mainly by enhancing the response to the attended stimulus, and by restricting the range of units responding to the stimulus, so as to exclude distractors and noise. The response gain associated with signal enhancement seems to occur in a way that increases the discriminability of the signal. This attention improves visual search by increasing the response to the target and by excluding distractors.	Level 4E
Humphreys, G.	Search via Recursive Rejection (SERR): A connectionist model of visual search. Cognitive Psychology 25, 43-110, 1993.	Review of Literature: In studies of visual search, a general distinction is often made between the processes involved when detection of a target is unaffected by the number of distractors in the field and those involved when search time increases linearly as a function of the number of distractors present. In the former case, processes are said to be "pre-attentive" and to operate in parallel across the visual field; in the latter, processing is said to require focal	Level 4E

		attention and to be spatially serial. In this paper, we present a connections model which performs visual search in parallel across a window defining the model's functional field. Elements in the field are allowed to group, using simple principles of similarity and spatial proximity. Search operates via the recursive rejection of areas of field where were stable and unambiguous grouping has been achieved. Performance of the model is unaffected by the number of distractors present when the distractors form a single group. As the number of competing distractor groups increases, there is an increased likelihood that targets are missed. Setting a response criterion to balance mi9ss rates generates serial increases in search time as a function of the number of distractors.	

Level of Evidence	Criteria
Level 1a	Population based studies, randomized prospective studies
Level 1b	Large non-population based epidemiological studies, meta-analysis or small randomized prospective studies
Level 2	Prospective Studies which can include, controlled, non-randomized, epidemiological, cohort or case-control studies
Level 3a	Historic which can include epidemiological, non-randomized, cohort or case-control studies
Level 3b	Case series: subjects compiled in serial fashion without control group, convenience sample, epidemiological studies, observational studies
Level 3c	Mannequin, animal studies or mechanical model studies
Level 4	Peer-reviewed works which include state of the art articles, review articles, organizational statements or guidelines, editorials, or consensus statements
Level 5	Non-peer reviewed published opinions, such as textbooks, official organizational publications, guidelines and policy statements and consensus statements
Level 6	Common practices accepted before evidence-based guidelines or common sense
Level 1-6E	Extrapolations from evidence which is for other purposes, theoretical analyses which is on-point with question being asked. Modifier E applied because extrapolated but ranked based on type of study.

Summary Table of Evidence

Place all the evidence listed in the previous sections in one of the following three columns using the follow approach:

1. *Place each article or report in one of the columns and in its own row*
2. *List articles with highest level of evidence first*
3. *In box place name of lead author and in parenthesis year published*
4. *In addition in each box put a one to two sentence summary of how the article either support, opposes or has no position with regard to the question(s)*

Supportive of Recommendation	Opposing Recommendation	No Position
Colvin, K., Dodhia, R. 2001		Scanning seemed to fixate on the middle of the field rather than all sides. Scanning the off-center windscreens was much less adequate.
Kasarskis, P. 2001		The more active the eyes, in a consistent, efficient pattern, the better a pilot performs.
DeMaio, J., 1976		The results of the present experiments recommend the use of a variety of scanning tasks in the UPT program to facilitate the more rapid development of adaptive scanning strategies.
Findlay, J no date		If the analysis is adequate to locate the search target, the eyes are moved to it, otherwise a new fixation location is selected. Particularly with large search displays, more strategic processes are also important that distribute fixations over the area to be searched.
McCarley, J 2004		Sensitivity and reaction times improved with practice. Observers were faster to fixate the target region of an image, and were both faster and more likely to recognize the target once they had fixated on or near it. Subjects were quicker to fixate the target region of an image as a result of practice,

		but were not more likely to do so. In other words, scanning became more efficient with practice but not more effective. Scanning efficiency was reduced when unfamiliar target shapes were introduced following practice, whereas effectiveness was not.
Horrey, W., 2006		For both experiments, task value, here a proxy for area of interest was the strongest predictor of scanning behavior. For tasks that had a high associated value, drivers tended to scan to the appropriate area more frequently, at the expense of other areas. Basically, the more instrumentation in an automobile, the less the area is scanned.
Blackwell, J., 1982		For both experiments, task value, here a proxy for area of interest was the strongest predictor of scanning behavior. For tasks that had a high associated value, drivers tended to scan to the appropriate area more frequently, at the expense of other areas. Basically, the more instrumentation in an automobile, the less the area is scanned.
Croft, J., No date available		Despite the fact that all spotters were trained to use a specific and systematic scan technique, they found no evidence that they followed their eye movements followed this prescribed. The data indicate that hit rates are rather poor, that the estimated visual coverage of the

		environment is low and that experience does not predict either environmental coverage or task success.
Seagull, F. 1997		The experimental results support the claim that a training procedure based on a systematic requirement to perform head movements within the HMD environment may improve the general ability of trainees to use this system in flight. Taken together, the two groups that experienced the target-capturing task involving head movement had a larger number of completed flights, longer flight durations in incomplete flights, and a higher rate of improvement with training. In contrast, with practice the three control groups reduced their head movement during HMD flights, whereas no change was observed in their head movement under normal flight conditions. Training head movement improves range of scanning.
Scharroo, J, 2001		The complexity of a single micropattern is inversely proportional to the amount of rotational and translational symmetry of the micropattern. If the micropatterns are randomly rotated and displaced, then irregularities arise when the patterns are highly complex. These irregularities introduce additional distractions. **Detectability will therefore become more difficult as complexity increases.**

Harrell, W. 2003		As the number of children in a pool increases, so does their informational value. Lifeguards, correspondingly, increase time taken to scan the pool and process information about these children, These findings suggest that lifeguards tend to assume that adults are “safer,” in the sense that they con look after themselves or have the swimming skills to avoid jeopardy. Lifeguards essentially simplify information gathering and processing tasks by concentrating their watchfulness on children.
Harrell, A. 1999		Vigilance by lifeguards increase, however, as children significantly exceeded the number of adult swimmers, presumably because the delegation of vigilance becomes more difficult and problematic for the untrained adults. As the absolute number of children increased, lifeguard scans declined.
Sireteanu, R. 2000		The lack of specificity of learning of visual search tasks suggests that what happens is not an improvement in the perception of a particular feature; rather, it seems that we are witnessing an improvement in search strategy.
Davis, E., 2003		: In the case of simple feature search, when the target had a critical feature (gap) or unique categorical attribute that distinguished it from all distractors, target location was easier. Increasing the number

		of distractors hurt search performance.
Verghese, P. 2003		This study shows that the probability of finding the target decreases as the number of locations monitored increases. Search performance is largely captured by a decision process acting on the output of oriented detectors. Search is affected by competing responses (If things look the same or similar, search takes longer).
Findlay, J., 2001		: Eye fixation on a target is affected by similar targets. It takes longer to find the target.
Bahcall, D. 2000		Saccadic eye movements are crucial for the performance of visual tasks. They bring selected objects to the fovea, providing a sequence of high-resolution views of the most informative sections of the scene. Two characteristics of natural scenes pose challenges to achieving effective saccadic control. First, the selected targets are usually surrounded by extraneous visual backgrounds. For saccades to be accurate, the influence of the backgrounds must be reduced or eliminated, and the saccadic programs based on the targets alone.
Araujo, C., 2001		Making a successful search is contingent on the appropriate saccadic planning. A successful search depended on the direction of the first saccade. All subjects scored better than 80% correct when the first saccade was made to the cluster that contained the

		target and less than about 30% correct when the first saccade was made in the opposite direction. This outcome confirms that the best strategy to ensure the highest proportion of correct reports is to use the probability cue to direct the first saccade to the cluster most likely to contain the target.
Findlay, J. 2006		It was noted that a systematic scan through a randomly arranged set of items might plausibly be carried out in a number of different ways. In this study, subjects used several different strategies.
Saarinen, J. 1991		Speed of focal visual attention can be quite fast. Observers lost information about the order of the numerals in the sequence even though they could still recognize the numerals. Practical application—the faster you scan the less you retain in memory.
Simonin, J., 2006		Five experienced computer users with ages between 24 and 29 and normal sight carried out 120 visual search tasks in scenes displayed on a 21" screen. Each scene included 30 realistic colour photos arranged along four different symmetrical structures. 1): Matrix-like (2D array), Elliptic (two concentric ellipses), Radial (eight radii along medians and diagonals of the screen),, and Random. For each scene, participants had to locate a pre-viewed photo in the scene, and to select it as fast as they could

		using the mouse. Target localization time is significantly shorter for Elliptic layouts then for Matrix layouts. In addition, scan path length is significantly smaller for Elliptic layouts compared to the three other structures.
McCarley, J., No date listed		Sensitivity and reaction times improved with practice. Observers were faster to fixate the target region of an image, and were both faster and more likely to recognize the target once they had fixated on or near it. Subjects were quicker to fixate the target region of an image as a result of practice, but were not more likely to do so. In other words, scanning became more efficient with practice but not more effective. Scanning efficiency was reduced when unfamiliar target shapes were introduced following practice, whereas effectiveness was not.
Lavine, R., 2002		With time-on-task, subjective fatigue ratings increased, dwell time defined as the total duration of fixations on target digits decreased, number of fixations decreased, and fixations were further from target digits in both conditions. Fixation durations did not change significantly with time or condition. Off-target visual scan-paths were less frequently followed by hits than were on-target scan-paths in both conditions. With the SBC, fixations were closer to target digits and hit rates

		increased.
Verghese, P. 2001		Attention acts mainly by enhancing the response to the attended stimulus, and by restricting the range of units responding to the stimulus, so as to exclude distractors and noise. The response gain associated with signal enhancement seems to occur in a way that increases the discriminability of the signal. This attention improves visual search by increasing the response to the target and by excluding distractors.
Humphreys, G. 1993		Elements in the field are allowed to group, using simple principles of similarity and spatial proximity. Search operates via the recursive rejection of areas of field where were stable and unambiguous grouping has been achieved. Performance of the model is unaffected by the number of distractors present when the distractors form a single group. As the number of competing distractor groups increases, there is an increased likelihood that targets are missed. Setting a response criterion to balance mi9ss rates generates serial increases in search time as a function of the number of distractors.

Textual Summary of Evidence:

Please provide a textual summary of the all of the evidence reviewed and explain in detail how these lead to the guidelines, recommendations and/or options which you are proposing

Definition of Terms:

Saccade: eye movement

There were no studies relating to lifeguard scanning patterns however, some of the information relates to distractions and ability to locate a target in a field of targets.

Though there was no supporting evidence relating to search patterns, there were some studies in which findings can be extrapolated and generalized for lifeguards scanning. The following is a summary of how the above studies could relate to scanning techniques for lifeguards.

1. While scanning, there is a tendency to observe what is in front of the scanner. Less time is spent searching areas to the right or left of the visual field. It appears that most personnel spend about one half of search time on only one segment (front) of their total assigned viewing area. Scanning patterns prescribed and taught were used infrequently. Observers followed the outline of structures within their fields of view (front). However, training head movement may improve the range of scanning.

2. Experience may have an effect on developing specific scanning patterns, and the ability to not dwell on one target too long. It also suggests that rather than using a rigid scanning pattern, experienced individuals use a flexible scanning strategy which allows them to emphasize important or difficult aspects of a display. Experienced individuals learn to attend to critical features more efficiently than do individuals with little or no experience.

3. Sensitivity to a stimulus and reaction times improve with practice. However, although scanning becomes more efficient with practice, it does not become more effective. Practice does sharpen observers' ability to recognize targets.

4. Detecting a target becomes more difficult as complexity increases. Also as the number of children in a pool increases, lifeguards have a tendency to observe them rather than adults. Scanning may be affected by the number of patrons in the facility. More incidents and rule violations interrupt scanning. Increasing the number of distractions has a negative effect on search performance.

5. The probability of finding a target decreases as the number of locations monitored increases. If the population looks similar, search takes longer.

6. There is a tendency for erroneous second saccades to be directed to an item sharing a target feature although the tendency is less marked than with the first saccades. In other words, if there are similarities between targets, attention is toward the similar object. Eye fixation on a target is affected by similar targets. It takes longer to find the target.

7. People have a tendency to develop their own scanning strategies. Subjects appear to use a scanning strategy that is not based on direction selection in any straightforward way.

8. People are capable of scanning very quickly. However, the faster you scan, the less you retain in memory.

9. Elliptic Scanning may result in less time needed to localize a target. Scan path lengths are shorter than Matrix, random or diagonal scan paths.

<u>Preliminary Guideline Document Section:</u>
Place your suggested recommendations into one or more of the three categories listed below and then briefly summarize the issue, your overall recommendations including answers to the question which was addressed as we should included it in the final document

Recommendations and Strength (using table below):

Standards:

Guidelines:
Lifeguard certifying agencies and lifeguard supervisors should emphasize:

1. Scanning all fields within a scanning zone with maximum head movement;
2. Having new lifeguards practice scanning with supervision and feedback;
3. Emphasize in training that when populations are similar, it takes longer to identify a potential incident;
4. Training should emphasize that distractions greatly affect the scanning process.

Options:

No Recommendations:

<u>Guideline Definitions for Evidence-Based Statements</u>

Statement	Definition	Implication
Standard	A standard in favor of a particular action is made when the anticipated benefits of the recommended intervention clearly exceed the harms and the quality of the supporting evidence is excellent. In some clearly identified circumstances, strong recommendation standards may be made when high-quality evidence is impossible to obtain and the anticipated benefits strongly outweigh the harms.	One should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.
Guideline	A guideline in favor of a particular action is made when the anticipated benefits exceed the harms but the quality of evidence is not as strong. Again, in some clearly identified circumstances, recommendations may be made when high quality evidence is impossible to obtain but the anticipated benefits outweigh the harms.	One would be prudent to follow a recommendation but should remain alert to new information.
Option	Options define courses that may be taken when either the quality of evidence is suspect or, level and volume of evidence is	One should consider the option in their decision-making.

	small or carefully performed studies have shown little clear advantage to one approach over another.	
No recommendation	No recommendation indicates that there is a lack of pertinent evidence and that the anticipated balance of benefits and harms is presently unclear.	One should be alert to new published evidence that clarifies the balance of benefit versus harm

Attach Any Lists, Tables or Summaries Created As Part Of This Review

(Please include any tables, lists of items or procedures and tables which you created as part of the review that would be helpful for final analysis or publication in the final document)

Unites States Lifeguarding Standard Coalition
Scientific Review Form

Author: Michael C. Giles, Sr.	**Organization Representing:** The University of Southern Mississippi Recreational Sports
Question: Scanning Techniques	**Date Submitted:** November 26, 2007

Question and Sub-Questions:
This should include the major question originally planned and any changes which occurred during the review process. Please also list any original sub-questions and the changes and those added during the review process.
What evidence is there to support the effectiveness of scanning techniques in identifying patrons in need of assistance?

Introduction/Background:
Provide any relevant background on the subject and the need to address this question.
Lifeguards show more concern when children are present. Distractions make lifeguards lose awareness of scanning (long days in heat, patrons asking questions, rule violations, loud noises). Jeff Ellis and Associates study recommend the need for a better scanning technique (2001).

Evidence Identification and Review
List the approach to gathering evidence. This should include any electronic databases searched with the terms used and numbers of articles found and reviewed. Also list any reports, prior evidence reviews analyzed and/or position papers evaluated.
Database Search Engines – 1. pubmed.gov 2. EBSCO Research data base 3. Google

Key Words – Lifeguards, scanning, techniques, vigilance, swimmer distress

12 articles reviewed

Summary of Key Articles/Literature/Reports/Data Found and Level of Evidence

(Please fill in the following table for articles that were used to create your recommendations and/or guidelines)

Author(s) and Year published	**Full reference**	**Summary of Article (if abstract available, first past abstract and then provide your summary**	**Level of Evidence (Using table below)**
Vogelsong, H., Griffiths, T., & Steel, D.	Vogelsong, H., Griffiths, T., & Steel, D. (2000). Reducing risk at aquatic facilities through lifeguard training. *Parks & Recreation, 35*(11), 66-73	Swimmers in guarded areas are often put at risk by inattentive lifeguards; training should include educating lifeguards on ways to prevent distractions and boredom. One such technique is the 5-Minute Scanning Strategy.	6
Harrell, A.W. & Boisvert, J.A.	Harrell, A.W. & Boisvert, J.A. (2003) An information theory analysis of duration of lifeguards' scanning. *Perceptual & Motor Skills, 93*(1), 129-134	Observers recorded the duration of scanning by six lifeguards in three indoor swimming pools. Duration of scanning was significantly predicted by the absolute numbers of child swimmers (<17 years) in the pools and when numbers of child swimmers were represented in terms of bits of information. Duration of scanning increased as a linear function of both numbers of children and child bits of information. Lifeguards appear to simplify the task of information processing and decision-making by concentrating on children as a more at risk group of swimmers. Duration of scanning was not significantly related to changes in number of adult swimmers.	1a

Harrell, W.A	Harrell, W.A. (1999) Lifeguards' vigilance: effects of child-adult ratio and lifeguard positioning on scanning by lifeguards. *Psychol Rep. 84*(1) 193-197	Scanning increased as a positive function of the ratio of children to adult swimmers, lifeguards became more concerned about the risks to children and the ability of nearby adult swimmers to monitor these children when the number of children significantly exceeded the number of adults. Absolute numbers of children, however, decreased number of scans, possibly because of greater number of incidents and rule violations requiring lifeguards' attention which competed with watching the pool. Lifeguards were more likely to scan a pool area when they were in elevated towers versus standing on the pool decks. Lifeguards' scanning declined later in the day, possibly due to fatigue or because of competing activities of pool maintenance.	1a
Schwebel, D.C., Lindsay S., & Simpson, J	Schwebel, D.C., Lindsay S., & Simpson, J. Brief report: a brief intervention to improve lifeguard surveillance at a public swimming pool. *J Pediatr. Psychol. 32*(7), 862-868	Observational data on patron risk-taking and lifeguard attention, distraction, and scanning were collected at a public swimming pool, both before and after a brief intervention. The intervention was designed to increase lifeguards' perception of susceptibility of drowning incidents, educate about potential severity of drowning, and	1a

		help overcome perceived barriers about scanning the pool. Post intervention lifeguards displayed better attention and scanning and patrons displayed less risky behavior. Change was maintained for the remainder of the season.	
Smith, T	Smith, T. (2006). Seeing is believing. *Parks and Recreation, 41*(11). 36-38	The Vigilance Voice. . Approach the guard, making sure you have the same vantage as they do, and have them articulate what they see on each one of their scans. Make sure to take notes, and pay attention to the things they aren't seeing such as risky behaviors, risky guests, problem areas of the pool, etc. Stay with them for an entire rotation. Vigilant Voice was added due to 2 unseen distressed swimmers at the authors' facility.	6
None	(2002) Study shows lifeguards can't always see everything. *Parks and Recreation. 37*(2)	Approximately 500 tests were performed onsite during the months of June, July and August at more than 90 U.S. pools. In each test, a manikin was placed underwater in the pool; a tester started the clock when it was fully submerged. Results showed it took 1 minute and 14 seconds for lifeguards to spot the manikin. Lifeguards noted the presence of the manikin 9% of the tests within 10 seconds, and in 30 seconds	1b

		or less in 43% of the tests. In 41% of the tests it took over one minute; it took more than three minutes in 14% of the tests.	
The Applied Anthropology Institute (Sept 2001)	Executive Summary Bibliographic Study of Lifeguard Vigilance	The maintaining of lifeguard vigilance at a high and constant level throughout the surveillance period is particularly difficult due to the nature of the task. The low number of critical signals, the high number of non-critical signals, the monotony, the unfavorable physical conditions and the organization of a specific activity make constant vigilance difficult.	2
Griffiths, Tom (Feb 1996)	Lifeguard behaviors: a century of safety? – includes related article on visual observation techniques and results of 1995 National Lifeguard Survey	With survey data older more experienced guards reported that they were significantly better trained, more confident, capable of watch large water surface areas and greater numbers of swimmer than younger less experienced guards. A second point is that a significant number of guards did not know how to scan and thought they were "less than very well trained". And were not supervised often enough. Last point training agencies have shifted focus from life saving and rescue to stressing preventive lifeguarding.	1b

Griffith, Tom (Feb 1996)	Scanning for the unexpected. *National Recreation and Parks Association*	Six major scanning patterns discussed with the purpose of observing swimmers and preventing the lifeguard from becoming bored, disinterested or inattentive. The increased level of skill and knowledge will directly influence the lifeguards preparedness and capability to properly handle hazardous situations.	1b
Griffiths, T.; Chambers, V.; Steel, D. (1995)	Systematic scanning for lifeguards – survey	Article intended to investigate observational techniques currently used by lifeguards to monitor swimming areas. During the survey when asked if specific training techniques would be helpful, 85% answered yes. Also, interesting was the response from lifeguards on how to stay alert and prevent boredom while on duty 30% responded that physically moving around and/or singing or listening to music was the most helpful.	1a
Griffiths, Tom (2004)	A Master Scan. www.aquaticssafetygroup.com	The need to study all variables such as: those that are physical, mental and psychophysiological should be measured along with the effectiveness of scanning while on duty.	1a
Griffiths, Tom (2005)	The Vigilant Lifeguard. www.aquaticssafetygoup.com	The findings of this article supported a basic tenet of the inverted U: as stress and arousal increase	1a

		performance decreases. Simply stated, moderate levels of arousal produced the best performance. Excessive high levels of arousal sometimes produced catastrophic performance.	

Level of Evidence	Criteria
Level 1a	Population based studies, randomized prospective studies
Level 1b	Large non-population based epidemiological studies, meta-analysis or small randomized prospective studies
Level 2	Prospective Studies which can include, controlled, non-randomized, epidemiological, cohort or case-control studies
Level 3a	Historic which can include epidemiological, non-randomized, cohort or case-control studies
Level 3b	Case series: subjects compiled in serial fashion without control group, convenience sample, epidemiological studies, observational studies
Level 3c	Mannequin, animal studies or mechanical model studies
Level 4	Peer-reviewed works which include state of the art articles, review articles, organizational statements or guidelines, editorials, or consensus statements
Level 5	Non-peer reviewed published opinions, such as textbooks, official organizational publications, guidelines and policy statements and consensus statements
Level 6	Common practices accepted before evidence-based guidelines or common sense
Level 1-6E	Extrapolations from evidence which is for other purposes, theoretical analyses which is on-point with question being asked. Modifier E applied because extrapolated but ranked based on type of study.

Summary Table of Evidence

Place all the evidence listed in the previous sections in one of the following three columns using the follow approach:

5. *Place each article or report in one of the columns and in its own row*
6. *List articles with highest level of evidence first*
7. *In box place name of lead author and in parenthesis year published*
8. *In addition in each box put a one to two sentence summary of how the article either support, opposes or has no position with regard to the question(s)*

Supportive of Recommendation	Opposing Recommendation	No Position
Griffiths, Tom (1996) – key information is that experienced lifeguards using various methods of surveillance feel like they are better able to perform their duties	**The Applied Anthropology Institute (2001) – article suggested additional automatic drowning accident detection device was necessary to supplement lifeguard vigilance**	**Harrell, A.W. & Boisvert, J.A. (2003) – authors offered data only no specific conclusions**
Griffiths, Tom (1996) – description of 6 major scanning patterns that can be used along with movement by the lifeguard to increase attentiveness and responsiveness	**Schwebel, D.C., Lindsay S., & Simpson, J. - the intervention was necessary to increase lifeguards' perception of susceptibility of drowning incidents, educate about potential severity of drowning, and help overcome perceived barriers about scanning the pool**	**Harrell, A.W. (1999) – authors offered data only no specific conclusions**
Griffiths, T.; Chambers, V.; Steel, D. (1995) – 85% of lifeguards surveyed stated that specific training techniques in surveillance and scanning would be helpful		***Parks and Recreation* (2002) – data information but proposed no solutions to the problem of poor vigilance**
Griffiths, Tom (2004) – the process of scanning and remaining vigilant is a comprehensive and vitally important task. Research is needed on how to get lifeguards to maintain		

vigilance after long hours of boredom		
Griffiths, Tom (2005) lifeguards need to stay focused and relaxed even in a stressful environment. Theses are the most important components of their success.		
Vogelsong, H., Griffiths, T., & Steel, D. (2000) – Training should include educating lifeguards on ways to prevent distractions and boredom		
Smith, T. (2006) – this method of scanning teaches verbalizing what the lifeguard is seeing in the pool.		

<u>Textual Summary of Evidence:</u>
Please provide a textual summary of the all of the evidence reviewed and explain in detail how these lead to the guidelines, recommendations and/or options which you are proposing

After review of 12 articles, seven articles were supportive of specific lifeguard vigilance. Two presented opposing views and three formed no position but offered information.

The evidence that I reviewed supports the importance of developing scanning techniques that raise the level of competence and responsiveness of the lifeguard. Combinations of eye movement in difference patterns over the areas of responsibility and physical movement by the lifeguard may serve as a proper technique for lifeguarding.

<u>Preliminary Guideline Document Section:</u>

Place your suggested recommendations into one or more of the three categories listed below and then briefly summarize the issue, your overall recommendations including answers to the question which was addressed as we should included it in the final document

Recommendations and Strength (using table below):

Standards:

Guidelines: The evidence that I reviewed supports the importance of developing scanning techniques that raise the level of competence and responsiveness of the lifeguard. Combinations of eye movement in difference patterns over the areas of responsibility and physical movement by the lifeguard may serve as a proper technique for lifeguarding.

Options:

No Recommendations:

<u>Guideline Definitions for Evidence-Based Statements</u>

Statement	Definition	Implication
Standard	A standard in favor of a particular action is made when the anticipated benefits of the recommended intervention clearly exceed the harms and the quality of the supporting evidence is excellent. In some clearly identified circumstances, strong recommendation standards may be made when high-quality evidence is impossible to obtain and the anticipated benefits strongly outweigh the harms.	One should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.
Guideline	A guideline in favor of a particular action is made when the anticipated benefits exceed the harms but the quality of evidence is not as strong. Again, in some clearly identified circumstances, recommendations may be made when high quality evidence is impossible to obtain but the anticipated benefits outweigh the harms.	One would be prudent to follow a recommendation but should remain alert to new information.
Option	Options define courses that may be taken when either the quality of evidence is suspect or, level and volume of evidence is small or carefully performed studies have shown little clear advantage to one approach over another.	One should consider the option in their decision-making.
No	No recommendation indicates that there is a	One should be alert to new

recommendation	lack of pertinent evidence and that the anticipated balance of benefits and harms is presently unclear.	published evidence that clarifies the balance of benefit versus harm

Attach Any Lists, Tables or Summaries Created As Part Of This Review

(Please include any tables, lists of items or procedures and tables which you created as part of the review that would be helpful for final analysis or publication in the final document)