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.
BREAKS (INTERRUPTIONS OF DUTY)

Question
- How long should a lifeguard be assigned to continually watch the water before interruption of duty?

Ancillary Questions
- Should a lifeguard be assigned to continually watch the water for more than 30 minutes without a break?
- How long a break should a lifeguard receive between assignments to watch the water?

Introduction
Water surveillance is a key assignment of lifeguards. Unless a situation in which people are endangered or in distress is recognized, an effective response to prevent death or injury is impossible. By vigilantly watching those in the water, lifeguards can observe behaviors and hazards that can be stopped or modified to prevent injury and death, and can promptly respond in case rescue efforts are needed.

Many factors affect an individual’s ability to effectively perform lifeguarding tasks, including personal characteristics, physical surroundings, and time. It is well established that the ability to concentrate on a given task declines over time, and although time is a factor that can be controlled, the length of time that a lifeguard should be assigned to water surveillance has not been defined. In many settings, the watch is limited to 1 hour.

Evidence Summary
Duration of watch: Evidence from three randomized studies showed that over a 30-minute period, vigilance declines; two additional literature reviews also indicated that vigilance declines over time. The decline was linear in one study and not linear in another. In one study that lasted 2 hours, the decline was greatest in the first 30 minutes and more gradual in the next three 30 minute periods.

Breaks: One study indicated that a 30-minute break after a vigilance task can fully “reset” vigilance.

Consensus Recommendation
Standards:
No Recommendations:
- Evidence from three high-level studies in laboratory settings and other industry standards and recommendations indicates that vigilance declines during the first 30 minutes of tasks. While a shorter period of scanning duty may be better, extrapolation to the lifeguard setting is difficult, because the risks of decreased vigilance over time may be offset by unique aspects of lifeguarding duties, including risks induced by frequent changing of lifeguards. Therefore, a recommendation cannot be made for an optimal length of time for a lifeguard shift.
United States Lifeguarding Standard Coalition
Scientific Review Form

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<tr>
<th>Author: B. Chris Brewster</th>
<th>Organization Representing: United States Lifesaving Association</th>
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<tr>
<td><strong>Question:</strong> How long should a lifeguard be assigned to continually watch the water before interruption of duty?</td>
<td><strong>Date Submitted:</strong> November 19, 2007</td>
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**Question and Sub-Questions:**

Primary Question: How long should a lifeguard be assigned to continually watch the water before interruption of duty?

Sub-Question (by author): How long a break should a lifeguard receive between assignments to watch the water?

Sub-Question (by author): What steps can be taken to favorably influence vigilance?

**Introduction/Background:**

Water surveillance is a key assignment of lifeguards. Unless people who are endangered or in distress are recognized, an effective response to prevent death or injury is impossible. By vigilantly and effectively watching water users in an area of responsibility, lifeguards can observe behaviors and hazards that can be ameliorated to prevent injury and death, and can respond in a timely manner to effect successful rescues.

It is well accepted and scientifically established that the ability to concentrate on a given task declines over time. Mackworth (1948) quoted Shakespeare on the subject:

“For now they are oppress’d with travel, they
Will not, nor cannot, use such vigilance
As when they are fresh.” – The Tempest, Act 3, Scene 3.

Mackworth (1957) defined vigilance as, “… a state of readiness to detect and respond to certain specified, small changes occurring at random time intervals in the environment.” The question posed here is what the optimal amount of time is that a lifeguard should be assigned before being relieved, to ensure maximum concentration and thus maximum safety for those under surveillance. Related questions are how long of a break should be provided before the lifeguard is again assigned to water surveillance and what steps might be taken to favorably influence vigilance.

**Evidence Identification and Review**

The reviewer visited the medical library of the University of California at San Diego on several occasions and used the computer system to search all available databases using terms such as:
vigilance, attention, attentiveness, scanning, vigilance decrement, target monitoring, boredom, heat stress, and sleep deprivation. In addition, where appropriate, references listed in pertinent articles were reviewed. The reviewer also benefited by numerous research papers shared by Dr. Linda Quan, M.D., as a result of her search of the Seattle Children’s Hospital database. (Many papers were overlapping from these two sources.) In all, a total of 149 research articles published in peer reviewed medical publications were reviewed. Tom Griffiths, Ed.D., of Pennsylvania State University and a principle in the Aquatic Safety Research Group (apparently a for-profit company) was contacted, as he has expressed specific views and written on the subject at hand. In addition, the following texts were acquired and reviewed:

Vigilance and Attention; Mackworth, Jane F; Penguin 1970
Human Vigilance Performance; Davies, D.R. and Tune G.S.; 1970

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

<table>
<thead>
<tr>
<th>Author(s) and Year published</th>
<th>Full reference</th>
<th>Summary of Article (abstract where available)</th>
<th>Level of Evidence (Using table below)</th>
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<tr>
<td>Adams, Jack; 1956</td>
<td>Vigilance in the Detection of Low Intensity Stimuli; Journal of Experimental Psychology; 1956, v. 52, n. 3</td>
<td>61 airmen were subjected to a randomized study evaluating the ability to detect small, low-intensity, aperiodically presented visual stimuli (10 per minute) over a 110 minute period and to determine how they did after a 10 minute break. All groups showed a steady decline in proficiency over time. All groups improved with rest.</td>
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<td>Anderson, C. and Horne, J.A.; 2006</td>
<td>A high sugar content, low caffeine drink does not alleviate sleepiness, but may worsen it; Human Psychopharmacology; 2006, 21, 299 – 303</td>
<td>Although the ingestion of high levels of glucose might have a short acting alerting effect, there is evidence of an ensuing enhancement of sleepiness in people already sleepy. Some 'energy drinks' contain large quantity of sugars. We compared 250 ml of a well known 'energy drink' (42 g sugars, containing a low [30 mg] level of caffeine for 'flavouring') with a nil sugar nil caffeine, similar tasting control. These were given a week apart, in a repeated measures, double blind, balanced design, to 10 participants sleep restricted to 5 h the prior night. They had a light lunch, consumed a drink at 13:50 h, and 10</td>
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3 min later underwent 3 x 30 min consecutive periods at a reaction time (RT) task (the Psychomotor Vigilance Test), separated by 3 min breaks when self-ratings of sleepiness were made. The energy drink did not counteract sleepiness, and led to slower RTs and more lapses during the final 30 min session, around 80 min after consumption.

Azrin, Nathan H.; 1958

Some Effects of Noise on Human Behavior; J Exp Anal Behav. 1958 April; 1(2): 183–200

The subjects were 80 soldiers aged 17–25. They were conditioned according to a fixed-interval: and fixed-ratio schedule of target presentation, and various conditions of noise were introduced. It was found that the degree of control exerted by noise over behavior was largely a function of whether the noise had any differential relation to the target or to the response. When noise, or its absence, was used as a discriminative stimulus for the target, responding came under the control of the noise, or its absence. Similarly, when intense noise, or its absence, was made contingent upon response, the pattern and frequency of responding were found to vary as a function of the conditions of noise presentation. When the noise was not presented in some differential relation to the target or the response, its major effects were transient and largely predictable on the basis of stimulus change.

Ballard, JC; 1996


Results of empirical studies using computerized tests of sustained attention are summarized. Factors that affect vigilance performance fall into three broad categories: task parameters, environmental or situational factors, and subject characteristics. Complex interactions of factors from each category affect performance further. Such interactions may help to explain inconsistencies in the literature.
Becker AB, Warm JS, Dember WN, Hancock PA; 1995


Seventy-two students (1/2 male and ½ female) aged 17 – 33 were used as subjects. This study examined the effects of exposure to intermittent jet aircraft noise (70 dBA or 95 dBA maximum intensity) and knowledge of results concerning signal detections (hit-KR) on performance efficiency and perceived workload in a 40-min visual vigilance task. The noise featured a Doppler-like quality in which planes seemed to approach from the monitor's left and recede to the right. Perceptual sensitivity (d') was poorer in the context of noise than in quiet but only in the presence of hit-KR. The lack of noise-related performance differences in the absence of hit-KR most likely reflected a "floor effect" rather than some special relation between noise and feedback. When compared to subjects performing in quiet, those who operated in noise were less able to profit from hit-KR, a result that may reflect the effects of noise on information processing. In addition to its negative effects on signal detectability, noise elevated the perceived workload, as measured by the NASA-TLX. This effect was robust; it was independent of the presence of hit-KR, even though hit-KR generally lowered the overall level of perceived workload. The results provide the initial experimental demonstration that perceived workload is a sensitive measure of the effects of aircraft noise in monitoring tasks.

Broadbent, D.E.; 1964

Vigilance; Br Med Bull. 1964 Jan;20:17-20

As research on vigilance increases, it has become evident that no one theory will account for all the phenomena. Attempts have been made to explain poor performance as due to low expectancy, low arousal, distraction, and
the accumulation of inhibition; but each of these explanations in inconsistent with some of the facts. We may, however, be on the verge of combining the various points of view into a single description using the statistical decision theory of Tanner and Swets.

Bunce, D.; 2002

Age differences in perceived workload across a short vigil; Ergonomics. 2002 Oct 20;45(13):949-60

Fifty employees of a UK based charity organization helping developing countries were invited to take part in the research. Twenty-six younger individuals aged 16 to 35 years (14 women), and 24 older individuals aged 45 to 65 years (11 women) formed the two age groups. Mean ages for younger and older groups were 27.81 and 52.17 years respectively. The main objective of this research was to investigate age differences in the perceived workload associated with the performance of a demanding, high event rate, vigilance task. Younger participants (n=26) aged 16 to 35 years (M=27.8) and older participants (n=24) aged 45 to 65 years (M=52.2) completed perceived workload scales (NASA-TLX) following a brief practice session (pretest) on the vigilance task, and then again following a test session (posttest) lasting nine minutes. In relation to the vigilance task, a statistically significant performance decrement was identified, but there was no evidence that performance differed according to age in respect to that decrement. However, a dissociation was found in relation to the perceived workload ratings: while no age differences were found in vigilance performance, the workload ratings revealed older participants to perceive a significantly greater increase in workload from pretest to posttest. These findings are considered theoretically in relation to the demands placed upon attentional resources, and their implications for both laboratory-based
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<td>Caggiano, D.M. and Parasuraman, R.; 2004</td>
<td>The role of memory representation in the vigilance decrement; Psychon Bull Rev. 2004 October ; 11(5): 932–937.</td>
<td>Working memory load is critically important for the overall level of performance on vigilance tasks. However, its role in a key aspect of vigilance—sensitivity decrement over time—is unclear. We used a dual-task procedure in which either a spatial or a nonspatial working memory task was performed simultaneously with a spatial vigilance task for 20 min. Sensitivity in the vigilance task declined over time when the concurrent task involved spatial working memory. In contrast, there was no sensitivity decrement with a nonspatial working memory task. The results provide the first evidence of a specific role for working memory representation in vigilance decrement. The findings are also consistent with a multiple resource theory in which separate resources for memory representation and cognitive control operations are differentially susceptible to depletion over time, depending on the demands of the task at hand.</td>
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<td>Childs E, de Wit H., 2006</td>
<td>Subjective, behavioral, and physiological effects of acute caffeine in light, nondependent caffeine users; Psychopharmacology (Berl). 2006 May;185(4):514-23</td>
<td>RATIONALE: Caffeine produces mild psychostimulant effects that are thought to underlie its widespread use. However, the direct effects of caffeine are difficult to evaluate in regular users of caffeine because of tolerance and withdrawal. Indeed, some researchers hypothesize that the psychostimulant effects of caffeine are due largely to the reversal of withdrawal and question whether there are direct effects of caffeine consumption upon mood, alertness, or mental performance in nondependent individuals. OBJECTIVE: This study investigated the physiological, subjective, and behavioral effects of 0, 50, 150, and 450 mg caffeine in 102 light, nondependent caffeine users.</td>
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METHODS: Using a within-subjects design, subjects participated in four experimental sessions, in which they received each of the four drug conditions in random order under double blind conditions. Participants completed subjective effects questionnaires and vital signs were measured before and at repeated time points after drug administration. Forty minutes after the capsules were ingested, subjects completed behavioral tasks that included tests of sustained attention, short-term memory, psychomotor performance, and behavioral inhibition. RESULTS: Caffeine significantly increased blood pressure, and produced feelings of arousal, positive mood, and high. Caffeine increased the number of hits and decreased reaction times in a vigilance task, but impaired performance on a memory task. CONCLUSION: We confirm that acute doses of caffeine, at levels typically found in a cup of coffee, produce stimulant-like subjective effects and enhance performance in light, nondependent caffeine users. These findings support the idea that the drug has psychoactive effects even in the absence of withdrawal.

Damos, D.L. and Parker, E.S.; 1994
High false alarm rates on a vigilance task may indicate recreational drug use; J Clin Exp Neuropsychol. 1994 Oct;16(5):713-22

Neuropsychologists need more sensitive methods to detect and measure recreational drug use in both research and clinical settings. In a study comparing the sensitivity of information processing tasks and neuropsychological instruments to detect early HIV-related cognitive decrements, 18 of 129 subjects tested positive for recreational drugs. Sixteen of these 18 subjects had elevated false alarm rates on one of the information processing tasks, the vigilance task. Another 45 subjects who tested negative for recreational drugs...
also had elevated false alarm rates. Neuropsychological measures of premorbid functioning, attention, speed of information processing, and manual dexterity were lower in the high false alarm subjects than in the remaining 66 drug-negative, low false alarm subjects. These results suggest that a high false alarm rate may reflect long-standing cognitive disturbances and the effects of drug use. The vigilance task may be a sensitive and efficient screening tool for recreational drug use.

<p>| Deaconson, T.F. et al.; 1988 | Sleep deprivation and resident performance; JAMA, Vol. 260 No. 12, September 23, 1988 | Cognitive and complex motor performance may be impaired by extended sleep deprivation, but objective data concerning the effects in residents of the sleep deprivation engendered by usual hospital on-call schedules are scant and conflicting. We studied three cohorts of surgical residents (N = 26) who were on call every other night. Each resident kept a sleep diary, gave a self-assessment of motivation and fatigue, and underwent a battery of psychometric tests each morning for 18 or 19 days. The psychometric tests measured cognition, discernment, visual and auditory vigilance, and rapid eye-hand coordination. Sleep deprivation was defined as the lack of four hours of continuous sleep during the preceding 24 hours, and it occurred during 89% of the on-call nights. Daily testing in a repeated-measures design allowed each participant to serve as his or her own control. Sleep deprivation did not affect overall cognitive or motor performance. Further analysis of the correlation between sleep parameters (total sleep and longest uninterrupted sleep interval) and performance on each component of the psychometric test battery identified changes in performance on some tests but only trivial effects due to sleep. The | 1a |</p>
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<tr>
<td>Dixit A, Vaney N, Tandon OP; 2006</td>
<td>Evaluation of cognitive brain functions in caffeine users: a P3 evoked potential study; Indian J Physiol Pharmacol. 2006 Apr-Jun; 50(2):175-80</td>
<td>Caffeine is one of the most widely consumed stimulant drugs of the modern world. It brings about a feeling of well-being, relaxation, increased alertness and concentration. Its effects have been studied on brain function and behavior using mood questionnaires, reaction time tests, memory tests, EEG and of late Event Related Potentials (ERPs). This study evaluates the response of caffeine on ERPs and Reaction Time (RT) using auditory &quot;oddball&quot; paradigm. Forty undergraduate medical students volunteered for the study and their ERPs and RT were recorded before and after 40 minutes of ingestion of caffeine. There was a non-significant decrease in latency of N1, P2, N2 and P3 and a significant decrease in Reaction Time after caffeine consumption. The amplitude of P3 showed a significant increase after intake of caffeine. The results of this study indicate that caffeine leads to facilitation of information processing and motor output response of the brain.</td>
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<td>Donald, Craig; 2001</td>
<td>People in control: human factors in control room design; Chapter 3 – Vigilance; Noyes J. and Bransby M. (Eds); ISBN 0852969783</td>
<td>Book review: This book results from the papers given at the conference in Bath in June 1999. The aim of the conference was to provide the latest knowledge of human-machine interactions within the context of control-room settings. As industrial processes become more automated there is increasing concern over the possibility of human error. The aim of this book is to help engineers to design better systems and processes to increase operational safety and efficacy.</td>
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The chapters are grouped into three topics: human performance; methods, and control-room design. Case studies and examples are included throughout. Subjects covered include: vigilance and human error in control room situations; analysis and training of control room activities; and control room design, including alarm systems.

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<th>Author(s)</th>
<th>Title</th>
<th>Abstract</th>
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<td>Donderi, D.C.; 1994</td>
<td>Visual acuity, color vision, and visual search performance at sea; Hum Factors. 1994 Mar;36(1):129-44.</td>
<td>Visual acuity and color vision were tested during a search and rescue exercise at sea. Fifty-seven watchkeepers searched for orange and yellow life rafts during daylight and for lighted and unlit life rafts at night with night vision goggles. There were 588 individual watches of one hour each. Measures of wind, waves, and weather were used as covariates. Daytime percentage detection was positively correlated with low-contrast visual acuity and negatively correlated with error scores on Dvorine pseudoisochromatic plates and the Farnsworth color test. Performance was better during the first half-hour of the watch. Efficiency calculations show that color vision selective screening at one standard deviation above the mean would increase daylight search performance by 10% and that one standard deviation visual acuity selection screening would increase performance by 12%. There was no relationship between either acuity or color vision and life raft detection using night vision goggles.</td>
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<td>Froom P; Caine Y, Shochat I, Ribak J; 1993</td>
<td>Heat stress and helicopter pilot errors; J Occup Med. 1993 Jul;35(7):720-4</td>
<td>Helicopter pilots are subjected to degrees of heat stress that under laboratory conditions result in decreased performance. However, the effect of heat stress on the frequency of helicopter pilot errors is uncertain. The purpose of this study is to determine whether there is an association between ambient heat stress and pilot error. The</td>
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records of 500 helicopter accidents and incidents due to pilot error during the months May through October were selected at random. On the day of the event, ambient dry bulb and wet bulb temperatures were recorded and compared to temperature and humidity readings on 1000 days chosen at random over the same time period, after eliminating days where events occurred. There was a significant difference between the dry temperature distributions of the days with pilot error compared with the control group (chi squared = 47.54, P < .0001). A dose-response relationship was found, with a significantly lower risk when ambient dry bulb temperatures were 25 to 29 degrees C (odds ratio, 0.6; 95% confidence interval, 0.5 to 0.8, P < .0001), an increased risk of 1.6 (1.3 to 2.0, P < .0001) at 30 to 34 degrees C, and the highest risk at 35 degrees C or more (6.2, 95% confidence interval, 2.1 to 21.8, P < .0002). There is a dose-response relationship between ambient heat stress and pilot error in Israel military helicopter pilots. This is the first study outside the laboratory showing a connection between heat stress and accidents due to human error. Further studies are required to substantiate our findings and to determine whether extrapolation to other settings is warranted.

Grier RA, Warm JS, Dember WN, Matthews G, Galinsky TL, Parasuraman R; 2003

The vigilance decrement reflects limitations in effortful attention, not mindlessness; Hum Factors. 2003 Fall;45(3):349-59

Robertson, Manly, Andrade, Baddeley, and Yiend (1997) proposed that the decline in performance efficiency over time in vigilance tasks (the vigilance decrement) is characterized by "mindlessness" or a withdrawal of attentional effort from the monitoring assignment. We assessed that proposal using measures of perceived mental workload (NASA-TLX) and stress (Dundee Stress State Questionnaire).
Two types of vigilance task were employed: a traditional version, wherein observers made button-press responses to signify detection of rarely occurring critical signals, and a modified version, developed by Robertson et al., to promote mindlessness via routinization, wherein button-press responses acknowledged frequently occurring neutral stimulus events and response withholding signified critical signal detection. The vigilance decrement was observed in both tasks, and both tasks generated equally elevated levels of workload and stress, the latter including cognitions relating to performance adequacy. Vigilance performance seems better characterized by effortful attention (mindfulness) than by mindlessness. Actual or potential applications of this research include procedures to reduce the information-processing demand imposed by vigilance tasks and the stress associated with such tasks.

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<th>Author(s)</th>
<th>Publication Details</th>
<th>Abstract/Note</th>
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<tr>
<td>Griffiths, Tom; 2001</td>
<td>Every 30 minutes; Aquatics International, 2001, June, 10</td>
<td>No Abstract Available: Author recommends that supervisors check the performance of lifeguards once every 30 minutes, providing “constant encouragement” while doing so, to help ensure lifeguard vigilance.</td>
<td>5-E</td>
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<tr>
<td>Griffiths, Tom; 2002</td>
<td>The vigilant lifeguard; Aquatics International 2002, May</td>
<td>No Abstract Available: Author suggests that boredom, heat and other factors negatively impact lifeguard vigilance. He recommends lifeguard breaks every 20 minutes, protecting lifeguards from heat, and working in pairs under certain circumstances.</td>
<td>5-E</td>
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<td>Jarvis, M.J.; 1993</td>
<td>Does caffeine intake enhance absolute levels of cognitive performance?; Psychopharmacology (Berl). 1993;110(1-2):45-</td>
<td>The relationship between habitual coffee and tea consumption and cognitive performance was examined using data from a cross-sectional survey of a representative sample of 9003 British adults (the Health and Lifestyle Survey). Subjects completed tests of simple reaction time, choice reaction time,</td>
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incidental verbal memory, and visuospatial reasoning, in addition to providing self-reports of usual coffee and tea intake. After controlling extensively for potential confounding variables, a dose-response trend to improved performance with higher levels of coffee consumption was observed for all four tests (P < 0.001 in each case). Similar but weaker associations were found for tea consumption, which were significant for simple reaction time (P = 0.02) and visuo-spatial reasoning (P = 0.013). Estimated overall caffeine consumption showed a dose-response relationship to improved cognitive performance (P < 0.001 for each cognitive test, after controlling for confounders). Older people appeared to be more susceptible to the performance-improving effects of caffeine than were younger. The results suggest that tolerance to the performance-enhancing effects of caffeine, if it occurs at all, is incomplete.


Sleep loss temporarily impairs vigilance and sustained attention. Because these cognitive abilities are believed to be mediated predominantly by the right cerebral hemisphere, this article hypothesized that continuous sleep deprivation results in a greater frequency of inattention errors within the left versus right visual fields. Twenty-one participants were assessed several times each day during a 40-h period of sustained wakefulness and following a night of recovery sleep. At each assessment, participants engaged in a continuous serial addition task while simultaneously monitoring a 150 degrees visual field for brief intermittent flashes of light. Overall, omission errors were most common in the leftmost peripheral field for all sessions, and did not show any evidence of a shift in
Laterality as a function of sleep deprivation. Relative to rested baseline and postrecovery conditions, sleep deprivation resulted in a global increase in omission errors across all visual locations and a general decline in serial addition performance. These findings argue against the hypothesis that sleep deprivation produces lateralized deficits in attention and suggest instead that deficits in visual attention produced by sleep deprivation are global and bilateral in nature.

Mackworth NH; 1948
The breakdown of vigilance during prolonged visual search; Quarterly Journal of Experimental Psychology; 1948, 1, p 6 - 21
(No abstract available.) Efficiency at signal detection declined over a two hour period

Matthews ML; 1986
The influence of visual workload history on visual performance; Hum Factors. 1986 Dec;28(6):623-32
Two experiments are reported that demonstrate that visual search for a signal from a number of potential signal sources in a sustained monitoring task is dependent upon previous load history. The present experiments demonstrate that performance under conditions in which visual load levels may change over time – either as a result of a change in the number of signal sources to be monitored or as a result of a change in the rate of signal presentation – cannot be predicted from static-load laboratory tasks.

Mavjee V, Horne JA; 1994
Boredom effects on sleepiness/alertness in the early afternoon vs. early evening and interactions with warm ambient temperature; Br J Psychol. 1994 Aug;85 ( Pt During the usual waking day there is a circadian propensity for sleepiness in the early afternoon. This contrasts with the circadian peak of alertness in the early evening. The former is apt to be masked by various exogenous factors. Alertness was compared at these times of day ('afternoon': 1200-1600 hours and 'evening': 1800-2200 hours) under contrasting environmental conditions: boring vs. stimulating ('interest') x warm
3:317-33 vs. cool ambient environment ('temperature'); making four combinations, with two times of day--i.e. eight independent conditions, each containing six subjects (N = 48). The emphasis of the study was to make the conditions 'natural' and not unpleasant--e.g. the environmental temperatures were not extreme and kept within a comfortable range. All conditions were run in a climatic chamber. Alertness was measured by reaction times and subjective sleepiness scales. Heart rate and body temperature were monitored continuously. Apart from time of day, 'interest' exerted a powerful effect that was significant for all variables, and was particularly potent in the afternoon. By comparison, the 'temperature' effects were minor. For our subjects the afternoon 'dip' centred between 1500 and 1530 hours, and displayed circadian characteristics.

Mazza, S., Pépin, J-L., Naëgelé, B., Plante, J., Deschaux, C. and Lévy, P.; 2005

Most obstructive sleep apnoea patients exhibit vigilance and attention deficits on an extended battery of tests; Eur Respir J 2005; 25:75-80

Excessive daytime sleepiness, fatigue and altered attention are often experienced by obstructive sleep apnoea (OSA) patients. Although attentional problems are presumably responsible for part of the daytime functioning impairment in OSA, thorough investigation is unusual. Clinicians usually attribute these symptoms to somnolence. In clinical practice, only one isolated test is generally used to assess vigilance and attentional defects. It was hypothesised that most OSA patients exhibit a broad range of attentional deficits, beyond impaired maintenance of wakefulness, and a specific battery of tests is needed to correctly assess them.

Three attentional tests were performed at 9:00, 11:00 and 13:30 h, measuring maintenance of wakefulness, sustained attention and divided attention. Twenty OSA patients (aged 51±12 yrs,
apnoea/hypopnoea index 45±22 h) and 40 control subjects (aged 48.4±9.9 yrs) were tested. OSA patients performed significantly less well on the three tests than the controls at the three sessions. This battery of tests demonstrated that 95% of patients had vigilance and/or attentional impairment. Impairment patterns varied between patients. Vigilance is impaired in obstructive sleep apnoea patients over a wide range of attentional processes. Not only is their ability to remain awake in monotonous situations impaired but their ability to maintain attention in more stimulating conditions is also affected. A single test of vigilance is not sufficient and could underestimate impaired vigilance and attention in some patients.

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<td>The present study examined the effects of task complexity and time on task on the monitoring of a single automation failure during performance of a complex flight simulation task involving tracking, fuel management, and engine-status monitoring. Two groups of participants performed either all three flight simulation tasks simultaneously (multicomplex task) or the monitoring task alone (single-complex task); a third group performed a simple visual vigilance task (simple task). For the multicomplex task, monitoring for a single failure of automation control was poorer than when participants monitored engine malfunctions under manual control. Furthermore, more participants detected the automation failure in the first 10 min of a 30-min session than in the last 10 min of the session, for both the simple and the multicomplex task. Participants in the single-complex condition detected the automation failure equally well in both periods. The</td>
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<td>The present study examined the effects of task complexity and time on task on the monitoring of a single automation failure during performance of a complex flight simulation task involving tracking, fuel management, and engine-status monitoring. Two groups of participants performed either all three flight simulation tasks simultaneously (multicomplex task) or the monitoring task alone (single-complex task); a third group performed a simple visual vigilance task (simple task). For the multicomplex task, monitoring for a single failure of automation control was poorer than when participants monitored engine malfunctions under manual control. Furthermore, more participants detected the automation failure in the first 10 min of a 30-min session than in the last 10 min of the session, for both the simple and the multicomplex task. Participants in the single-complex condition detected the automation failure equally well in both periods. The results support previous findings of inefficiency in monitoring automation and show that automation-related monitoring inefficiency occurs even when there is a single automation failure. Implications for theories of vigilance and automation design are discussed.</td>
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<tr>
<th>Putz, V; 1965</th>
<th>The effects of different modes of supervision on vigilance behaviour; Br J</th>
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<tr>
<td>Experiment I was run to determine if a closed-circuit television and a one-way window mode of supervision were as effective as the direct physical presence of an experimenter in inducing</td>
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enhanced levels of signal detection in a Mackworth-type vigilance task. A control condition of complete subject privacy was also examined. The results indicated that both the television and the window conditions had a positive effect on overall performance which was similar to that observed in the experimenter-presence condition; however, the performance decrement over the 90 min vigil was equivalent for the four modes. A second experiment involving the variable of camera position with an addition of a fourth 30 min. period yielded no significant differences between the camera positions, but overall performance in the television condition was again better than in the control condition. This study suggested that performance can be enhanced even without the physical presence of the experimenter.

Schwebel, D.; Lindsay, S.; and Simpson, J.; 2007

OBJECTIVES: Drowning is the second leading cause of unintentional death for American children in middle childhood, but behavioral research designed to prevent pediatric drowning is limited. This study tested the efficacy of a brief intervention to improve lifeguard attention and surveillance at a public swimming pool. METHOD: 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 help overcome perceived barriers about scanning the pool. RESULTS: Postintervention, lifeguards displayed better attention and scanning and patrons displayed less risky behavior. Change was maintained for the
CONCLUSION: Theoretically driven brief interventions targeting lifeguard attention and surveillance might prove effective in reducing risk of drowning in public swimming pools.

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<th>Reference</th>
<th>Description</th>
<th>Notes</th>
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<tr>
<td>See, Judi E.; Howe, Steven R.; Warm, Joel S.; Dember, William N; 1995</td>
<td>Meta-Analysis of the Sensitivity Decrement in Vigilance; Psychological Bulletin. 1995 Mar Vol 117(2) 230-249</td>
<td>1b</td>
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<td>Smit, A.; Eling, P.; and Coenen, A.; 2004</td>
<td>Mental effort causes vigilance decrease due to resource depletion; Acta Psychol (Amst). 2004 Jan;115(1):35-42</td>
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Observers' perceptual sensitivity to critical target events can deteriorate when they must remain alert for prolonged periods. The dominant characterization of this sensitivity decrement has been the R. Parasuraman and D. R. Davies (1977) taxonomy of vigilance, which attributes the decline in perceptual ability to the type of discrimination (successive-absolute vs simultaneous-comparative judgment) and the event rate (rate of stimulus presentation) required for task completion. According to the model, sensitivity decrements occur chiefly in tasks that couple successive discrimination with a high event rate. This meta-analysis of 42 vigilance studies attempted to refine the taxonomy by identifying other task characteristics related to the sensitivity decrement. The analysis confirmed that the magnitude of this sensitivity decrement is substantial and that it is a function of the type of discrimination and the event rate, but it also revealed that the current taxonomy should be revised to incorporate a new dimension: the sensory-cognitive distinction.

The resource view on vigilance performance was tested. First, a low demanding task was compared with a similar low demanding task in which stimulus presentation was less monotonous due to added, irrelevant, stimuli. The resource view, maintaining that vigilance is lowered by hard mental work, predicts that addition of irrelevant stimuli will not affect performance. The classic arousal theory, however, states...
that arousal drops due to monotonous stimulus presentation and predicts that decreasing monotony will enhance performance. Results showed that performance was unaffected by added stimuli. Second, we tested whether a high-demanding task (with identical stimulus presentation as the low demanding task, but different instruction) would cause a greater decline in performance than the low demanding task. Indeed, in the high-demanding task performance was affected most. In sum, it appears that vigilance decreases due to hard mental work, which requires many resources. Both overall performance and decrement in performance can be explained in terms of resources, and this suggests that vigilance tasks should be resource-demanding tasks, which do not have to be of long duration.


| Effects of sensory modality and task duration on performance, workload, and stress in sustained attention; Human Factors, 2004, v 46, n 2, 219 |
| The workload and stress associated with a 40-min vigilance task were examined under conditions wherein observers monitored an auditory or a visual display for changes in signal duration. Global workload scores fell in the midrange of the NASA Task Load Index, with scores on the Frustration subscale increasing linearly over time. These effects were unrelated to the sensory modality of signals. However, sensory modality was a significant moderator variable for stress. Observers became more stressed over time as indexed by responses to the Dundee Stress State Questionnaire, with evidence of recovery in the auditory but not the visual condition toward the end of the watch. This result and the finding that signal detection accuracy - although equated for difficulty under alerted conditions - favored the auditory mode, indicate that display modality and time on task should be considered carefully | 1b |
in the design of operations requiring sustained attention in order to enhance performance and reduce stress. Actual or potential applications of this research include domains in which monitoring is a crucial part, such as baggage screening, security operations, medical monitoring, and power plant operations.

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<tr>
<th>Author(s)</th>
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<tr>
<td>Taylor, W., Melloy, B., Dharwada, P., Gramapadhye, A., Toler, J.; 2004</td>
<td>The effects of static multiple sources of noise on the visual search component of human inspection. International Journal of Industrial Ergonomics 2004; 34: 195 – 2007</td>
<td>Visual inspection is a commonly used inspection method, but effects of noise on visual inspection have not been studied extensively. The objective of this study was to investigate the effects of noise on visual search performance. The effects of continuous, intermittent, and random noise conditions emitted from single and multiple sources on the accuracy of an inspector to perform easy and difficult inspection tasks was examined. When compared to the continuous noise treatment, random and intermittent noise patterns were shown to have negative effects on the easy search task accuracy. Additionally, the results indicate that single source noise enhances search performance of difficult tasks. A larger study would likely detect noxious effects of multiple noise sources on difficult search task performance.</td>
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<tr>
<td>Thackray, RI, Bailey, J, and Touchstone, R; 1977</td>
<td>The effect of increased monitoring load on vigilance performance using a simulated radar display; Federal Aviation Administration (USA) Civil Aeromedical Institute; July 1977</td>
<td>The present study examined the extent to which level of target density influences the ability to sustain attention to a complex monitoring task requiring only a detection response to simple stimulus change. The visual display was designed to approximate a futuristic, highly automated air traffic control radar display containing computer-generated alphanumeric symbols. Forty-eight male subjects, equally divided into three groups, were exposed to density levels of 4, 8, or 16 targets. Ten critical stimuli (signals) were randomly presented during each half-hour of the 2-hour session. Detection latency to the</td>
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critical stimuli in the 16-target condition was significantly greater than latency to the 4- and 8-target conditions. There was no evidence of performance decrement in the two lower density conditions. The 16-target condition showed a significant progressive increase in mean detection latency, which was primarily the result of an increase in long latencies. The hypothesized decline in attention associated with this condition appeared to be independent of any major change in arousal level.

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<tr>
<th>Author(s)</th>
<th>Title</th>
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<tr>
<td>Washburn DA, Taglialatela, L., Rice, P., Smith, J.; 2004</td>
<td>Individual differences in sustained attention and threat detection; Cognitive Technology, 2004, v 9, no 2, 30 – 33</td>
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<tr>
<td>Wilkinson, R; 1963</td>
<td>Aftereffect of sleep deprivation; J Exp Psychol. 1963 Nov;66:439-42.</td>
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<tr>
<td>Authors</td>
<td>Reference</td>
<td>Summary</td>
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<td>William Helton, Todd Hollander, Joel Warm,</td>
<td>Signal regularity and the mindlessness model of vigilance; Br J Psychol.</td>
<td>Performance fell below control levels (normal sleep on both nights). Ss were their own controls in a balanced design. This “after-effect” of sleep deprivation was the greatest in the morning and, unlike the direct effect of sleep deprivation, was apparent at the start of the test and increased little with time. This suggests disturbed diurnal rhythm as the cause rather than failure to make up for lost sleep.</td>
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<td>Gerald Matthews, William Dember, Matthew</td>
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<td>Wallaart, Gerald Beauchamp, Raja Parusuraman,</td>
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<td>Peter Hancock; 2005</td>
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<td>ROBERTSON, MANLY, ANDRADE, BADDELEY, and Yiend (1997) have proposed that detection failures in vigilance tasks result from a ‘mindless’ withdrawal of attentional effort from the monitoring assignment. To explore that view, they modified the traditional vigilance task, in which observers make button-press responses to signify the detection of rarely occurring critical signals, to one in which button-press responses acknowledge frequently occurring non-signal events and response withholding signifies signal detection. This modification is designed to promote a mindless withdrawal of attentional effort from the task through routinization. The present study challenges the validity of the mindlessness model by showing that with both types of task, observers utilize subtle patterns in the temporal structure of critical signal appearances to develop expectations about the time course of those appearances that affect performance efficiency. Such expectations enhance performance on the traditional vigilance task, but degrade performance on the modified task.</td>
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<tr>
<td>Williamson, A, and Feyer, A; 2000</td>
<td>Moderate sleep deprivation produces impairments in cognitive and motor performance</td>
<td>OBJECTIVES: To compare the relative effects on performance of sleep deprivation and alcohol. METHODS: Performance effects were studied in the same subjects over a period of 28 hours of sleep deprivation and after measured</td>
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equivalent to legally prescribed levels of alcohol intoxication; Occup Environ Med. 2000 Oct;57(10):649-55.

Doses of alcohol up to about 0.1% blood alcohol concentration (BAC). There were 39 subjects, 30 employees from the transport industry and nine from the army. RESULTS: After 17-19 hours without sleep, corresponding to 2230 and 0100, performance on some tests was equivalent or worse than that at a BAC of 0.05%. Response speeds were up to 50% slower for some tests and accuracy measures were significantly poorer than at this level of alcohol. After longer periods without sleep, performance reached levels equivalent to the maximum alcohol dose given to subjects (BAC of 0.1%). CONCLUSIONS: These findings reinforce the evidence that the fatigue of sleep deprivation is an important factor likely to compromise performance of speed and accuracy of the kind needed for safety on the road and in other industrial settings.

Wyon DP, Wyon I, Norin F; 1996

Effects of moderate heat stress on driver vigilance in a moving vehicle; Ergonomics, 1996, vol 39, no 1, 61 - 75

A total of 83 drivers, 51 males and 32 females, aged 25-65, were recruited to drive an apparently unmodified passenger car for 1 h over at least four laps of a predetermined route on public roads, which included seven sets of traffic lights and sections limited to 50, 70, 90 and 110 km/h. They were randomly assigned to one of two thermal conditions (21 or 27 degrees C), and drove only during the hours of daylight. A computer initiated unprepared signals to which drivers would normally be alert. Drivers responded by pressing a foot-switch and reporting verbally. Signals were selected at random from 21 possible signals, and were presented for up to 3 min, with a random delay of 30-180 s after each response or failure to respond. The negative effect of heat stress on vigilance was statistically significant. At 27 degrees C, the overall proportion of

1a
missed signals was 50% higher and response times were 22% longer than they were at 21 degrees C. These effects of heat were significant and proportionally greater in the second half-hour, for subjects < 40 years and for speeds below 60 km/h (i.e. in city traffic). The latter finding suggests that heat may have increased arousal, and there was some indication of a redistribution of attention away from the most peripheral signals at the higher temperature. Overt driving errors were observed significantly more often at 27 degrees C than at 21 degrees C for women only.

| Zwyghuizen-Doorenbos A, Roehrs TA, Lipschutz L, Timms V, Roth T.; 1990 | Effects of caffeine on alertness; Psychopharmacology (Berl). 1990;100(1):36-9 | The alerting effects of caffeine were assessed using a standard physiological measure of daytime sleepiness/alertness, the Multiple Sleep Latency Test (MSLT). Healthy young men (n = 24) were randomly assigned to receive caffeine 250 mg or placebo administered double blind, at 0900 and 1300 hours on each of 2 days. On the 3rd day both groups received placebo to test for conditioning to the alerting effects of caffeine. Each day sleep latency was measured at 1000, 1200, 1400, and 1600 hours and performance (divided attention at 1030 hours and auditory vigilance at 1430 hours) was assessed. Caffeine increased sleep latency (i.e., improved alertness) and auditory vigilance performance compared to placebo. Tolerance to the effects of caffeine on sleep latency developed over the four administrations. On the conditioning test (day 3) the group receiving caffeine the previous two days was more alert and performed better than the placebo group. | 1a |

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<tr>
<th>Level of Evidence</th>
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<tr>
<td>Level</td>
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<tr>
<td><strong>Level 1a</strong></td>
<td>Population based studies, randomized prospective studies</td>
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<tr>
<td><strong>Level 1b</strong></td>
<td>Large non-population based epidemiological studies, meta-analysis or small randomized prospective studies</td>
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<tr>
<td><strong>Level 2</strong></td>
<td>Prospective Studies which can include, controlled, non-randomized, epidemiological, cohort or case-control studies</td>
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<tr>
<td><strong>Level 3a</strong></td>
<td>Historic which can include epidemiological, non-randomized, cohort or case-control studies</td>
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<tr>
<td><strong>Level 3b</strong></td>
<td>Case series: subjects compiled in serial fashion without control group, convenience sample, epidemiological studies, observational studies</td>
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<tr>
<td><strong>Level 3c</strong></td>
<td>Mannequin, animal studies or mechanical model studies</td>
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<tr>
<td><strong>Level 4</strong></td>
<td>Peer-reviewed works which include state of the art articles, review articles, organizational statements or guidelines, editorials, or consensus statements</td>
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<tr>
<td><strong>Level 5</strong></td>
<td>Non-peer reviewed published opinions, such as textbooks, official organizational publications, guidelines and policy statements and consensus statements</td>
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<td><strong>Level 6</strong></td>
<td>Common practices accepted before evidence-based guidelines or common sense</td>
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<tr>
<td><strong>Level 1-6E</strong></td>
<td>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.</td>
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### Summary Table of Evidence

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

33. Place each article or report in one of the columns and in its own row
34. List articles with highest level of evidence first
35. In box place name of lead author and in parenthesis year published
36. 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)

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<thead>
<tr>
<th>Supportive of Recommendation</th>
<th>Opposing Recommendation</th>
<th>No Position</th>
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<tbody>
<tr>
<td><strong>Standard 1: Lifeguard Breaks</strong></td>
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<td>Mackworth (1948) – A ½ hour break was found to reset subjects to the level of vigilance prior thereto.</td>
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<tr>
<td><strong>Standard 2 and 3: Supervision and Encouragement</strong></td>
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<tr>
<td>Mackworth (1948) – Feedback and encouragement can lessen the vigilance decrement.</td>
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<td>Schwebel (2007) – A mid-summer meeting modeling good performance improved vigilance.</td>
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<td>Putz (1975) – Knowledge of monitoring (present or by camera) reduced the vigilance decrement well below that found by Mackworth.</td>
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<tr>
<td>Griffiths (2001) – Recommended checking on and encouraging the work of lifeguards every 30 minutes.</td>
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<td><strong>Standard 4: Sleep</strong></td>
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<td>Deaconson (1988) -- Found no reduction in performance due to sleep deprivation below four hours per night.</td>
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<td>Kendall (2005) – Sleep loss temporarily impairs vigilance and sustained attention.</td>
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<td>Williamson (2000) – Sleep deprivation caused effects</td>
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similar to alcohol intoxication.

Wilkinson (1963) – Sleep deprivation had lingering effects a day after a full night’s sleep.

**Standard 5: Temperature**

Ballard (1996) – Gradual exposure to temperatures greater than 90° impairs vigilance.

Wyon (1996) – Driver vigilance declined significantly from a car at 70° to a car at 81°.

Froom (1993) – Pilot errors were progressively greater at temperatures above 84°.

**Standard 6: Drug Use**

Damos (1994) – People assigned to a vigilance task who tested positive for recreational drugs (including marijuana, cocaine, opiates, benzodiazepines, or a combination of marijuana and cocaine) were more likely to demonstrate a high false alarm rate than were those who tested drug negative. (Other studies appear to indicate that regardless of actual intoxication rates, vigilance is lower in regular users of certain recreational drugs.)

**Standard 7: Caffeine**

Childs (2006) -- Caffeine, at doses found in commonly consumed beverages, produces net beneficial mood and performance-enhancing effects in light, nondependent users.

Zwyghuizen-Doorenbos (1990) -- Caffeine improved alertness and vigilance.

Jarvis (1992) -- Even for
habitual users of caffeine, consumption produced benefits to cognitive performance, and higher daily caffeine consumers tend to perform somewhat better than to low consumers.

**Standard 8: Sugar**

Anderson (2006) -- Energy drinks containing sugar, but little caffeine, have a negative longitudinal impact on vigilance. Sugar may provide a temporary boost (which is well documented), but the ensuing decline is significant and outweighs the benefits for a long-term vigilance task.

**Guideline 1: Drug Testing**

See Standard #6

**Guideline 2: Sleep Apnea**

See Standard #4

Mazza (2005) -- “When using an adequate panel of vigilance tests to assess the ability to remain awake, and to maintain selective, sustained and divided attention, a large majority of sleep apnea patients demonstrated attention defects.”

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**Textual Summary of Evidence**

**Introduction**

As explained in a meta-analysis by researcher Judi E. See, et al. (1995), “Vigilance or sustained attention refers to the ability of observers to maintain their focus of awareness and remain alert to stimuli for prolonged periods of time. The systematic study of vigilance had its origins in signal detection problems during World War II. After only about 30 min. on watch, airborne British radar observers began to miss the blips of light on their displays that indicated the presence of enemy submarines in the sea below. The Royal Air Force commissioned Norman H. Mackworth to study the problem in his laboratory. His investigations were to mark the beginning of over four decades of research aimed at discovering the factors that might account for what has come to be termed the vigilance decrement, or the decline in performance efficiency that occurs over time. The vigilance decrement has been replicated consistently since N.H. Mackworth’s initial
research, and it continues to be the most ubiquitous finding in vigilance experiments. The decline in performance is typically complete 20 to 35 min. into the session, and at least half of the final loss occurs during the initial 15 min. of the watch … As Dember and Warm (1979) pointed out, the most salient aspect of the decrement function is that it seems to stem simply from the necessity of looking or listening for a relatively infrequent signal for a prolonged period of time.”

While the author of this report reviewed some 149 research studies, it is apparent that even more studies are available, many of which were referenced in the studies reviewed. It seems reasonable that an even more thorough review would yield additional and very possibly different conclusions, but the body of vigilance research does seem to have many consistencies across studies, which are hopefully reflected herein.

Only a handful of research studies involve lifeguards or activities directly similar to lifeguarding. The age range of the subjects of most studies appears to be coincidentally similar to that of lifeguards. Most seem to involve college students, soldiers, and other younger people, as they have been readily available subjects for the researchers.

Many of the scenarios involved in the reviewed research involve relatively tedious circumstances, such as the Mackworth (1948) scenario requiring subjects to stare at the rough equivalent of a ticking clock. Typical studies appear to involve assigning subjects a task, which involves recognizing the presence of some sort of unusually occurring variable during the time period. For example, a computer screen may be put before the subject with various forms of meaningless information, but on occasion a specific “signal” character or symbol may appear and the subject is asked to note the presence; for example, by pressing a button. Failing to note the presence indicates a lack of vigilance that is tracked. As Smit et al. (2004) state, “The classic vigilance task [constructed by researchers] is a boring task of long duration.” That said, few studies involved test durations of more than two hours, many being much shorter.

The settings where lifeguards are assigned might be expected to be more stimulating – but also more visually cluttered and substantially larger, requiring head and eye movement – than the typical laboratory setting used in much of the vigilance research. Also, while some drowning victims may quickly and quietly submerge, more typical presentations involve some degree of surface struggle, which could be expected to take longer than the momentary “signal” produced in most vigilance research experiment – a signal that is either seen or not.

Thackray et al. (1977) cited others having, “… pointed out that modern operational monitoring tasks involving suprathreshold long-duration signals, extensive scanning of multiple stimuli, and complex decisional processes are so different from the simple vigilance task [in most research experiments] that to assume the existence of a comparable decrement function [in real life] is unwarranted on the basis of our present knowledge.” In other words, laboratory experiments may not have direct resonance for reality. In fact, Smit et al. (2004) found that as increased resources were required of the subject, due to a more complex task, vigilance decreased more rapidly: “… we suggest that true decrements in vigilance are present whenever high amounts of resources are required continuously. Consequently, we propose that it is not task duration per se, but rather resource demands that determine vigilance performance.” In a lifeguard environment, depending
upon the complexity of the area scanned (numbers of people, hazards present, etc.), mental resource demands would be relatively high compared with a simple laboratory setting.

Another key difficulty in applying existing vigilance research to a lifeguard setting is that in research, there is typically little or no negative outcome to the study subject for failure to perform to a high level, or for that matter incentive to perform well. Conversely, the lifeguard’s incentive is at the very core of the lifeguard’s responsibility. Failure of the lifeguard to maintain vigilance could result in death or deaths of human beings and negative employment consequences for the lifeguard. It could be surmised, absent research to the contrary, that a lifeguard watching an area to prevent death will be significantly more attentive than a study subject watching a computer screen for a relatively brief period to note the presence of a random blip.

With respect to this possibility, insights may be gleaned from a study by R.E. Perkins and A.B. Hill (1985), which hypothesized that boredom results when stimuli lack meaning to the person. According to their hypothesis, if stimuli have meaning to the person (e.g. a lifeguard watching patrons in various activities for the purpose of preventing death or injury, versus a ticking clock), the person may be less inclined to be bored and to therefore experience a vigilance decrement. However, Perkins’ and Hill’s hypothesis did not prove out in their experiments. Quoting from the study, “… no evidence emerged from the present studies to support [the] view that boredom is associated with a lack of meaningful stimulation.” If so, the mere fact that the lifeguard’s subject matter may have more meaning than in a laboratory setting may not have a salutary effect on maintaining vigilance. This however, was a hypothesis not proven in one study. Mavjee and Horne (1994) referenced the Perkins and Hill study as being in the minority of studies that found no link between boredom and alertness. Grier et al. (2003) determined that it was not mindlessness, meaning a withdrawal of attention over time, that might be considered comparable to boredom, but rather workload and stress that primarily contributed to the vigilance decrement. Helton et al. (2005) reached a similar conclusion that mindlessness was not a key factor in the vigilance decrement. This suggests, at minimum, that the research on the effects of boredom on alertness and vigilance are mixed.

All of the studies reviewed indicate that vigilance decreases over time, regardless of the time involved. Most involve at least one signal event over a given time period, few of which time periods were more than one hour. Most involve repeated signal events, sometimes in the dozens. As the meta-analysis of See et al. (1995) states, “Only eight of the 138 conditions included in the meta-analysis [of various research experiments] required simultaneous discriminations at event rates below 24 events per minute, and only 18 of them involved successive low-event-rate tasks … consequently, it is not certain whether the findings regarding the effects of these and other variables on vigilance performance do pertain to low-event-rate tasks as well.” With respect to drowning recognition and prevention, lifeguarding is a very low-event vigilance task beyond any identified studies.

Another issue with respect to the limitation of vigilance experiments is how simplistic many are. While a lifeguard may have to scan dozens of water users for sometimes subtle clues over areas that can be quite significant in scope (particularly at an ocean beach), many experiments involve a subject sitting in front of a computer screen, for example, and noting when an anomalous
Vigilance Decrement

The groundbreaking study on the vigilance decrement was that of Mackworth (1948) who reported on a “clock test” in which subjects were placed in a small, unremarkable room before an analog clock-like device for varying periods up to two hours in length, and asked to press a button each time the clock ticked twice, instead of once. This twice-ticking did not occur with complete randomness. For the first 20 minutes of each ½ hour, it occurred 12 times at irregular intervals. During the last ten minutes, it did not occur at all. This test was in some cases conducted for only one ½ hour period, but also duplicated for sequential one-hour and two-hour periods. For subjects assigned to watch for two hours, there was a 15.7% average miss rate in the first ½ hour, a 25.8% miss rate in the second ½ hour, a 26.8% miss rate in the third ½ hour, and a 28% miss rate in the fourth ½ hour.

Clearly, the average miss rate between the first and second ½ hours was fairly significant (10.1%) relative to the average miss rate decrements of the last three ½ hours (1%, then an additional 1.2%). Mackworth interpreted his data to indicate that the decline between the first ½ hour and second ½ hour were the greatest, which is clearly the case, using averages. A careful review of Mackworth’s research model and data however, suggests that Mackworth’s data might not be quite so clearly conclusive, as will be explained.

As noted, Mackworth designed his study such that 12 signals appeared before the subjects during the first ½ hour. Their timing was predetermined by Mackworth, and although they occurred at varying time intervals, all 12 had appeared by the 20th minute of the ½ hour. After that, no signals appeared for 10 minutes. There is thus no information, for example, on how the subjects might have performed in the 22nd minute or the 28th minute. The only data is for the first 20 minutes.

In the first ½ hour of Mackworth’s study, the average miss rate started at about 14%, then improved to about 8.5% by the 5th minute, then declined to about 21% by the 20th minute – the last signal provided in the first ½ hour. Considered from this perspective, while the average miss rate in the first ½ hour of Mackworth’s study was measured at 15.7%, which contrasts quite favorably to the subsequent ½ hour periods, it is actually only the average for the first 20 minutes. Moreover, from the start to minute 8, the miss rate averages about 12.9%. From the start to minute 15, it averages about 14.9%. After minute 15 to minute 20, it averages about 19%, ending with a miss rate of 21% at minute 20. Then, at the start of the second ½ hour period, the miss rate of the first signal was 20% (an improvement over minute 20 in the first ½ hour and the last time period then checked), while the average in the second ½ hour was 25.8%. Another limitation in Mackworth’s research was lack of randomness from subject to subject or ½ hour to ½ hour. The same front-loaded signals were offered to each subject, in each ½ hour, at precisely the same intervals.
Study limitations aside, See et al. (1995) allude to the best interpretation of existing data in their meta-analysis reported earlier, stating, “The decline in performance is typically complete 20 to 35 min. into the session, and at least half of the final loss occurs during the initial 15 min. of the watch …” Indeed, it seems entirely possible, though impossible to know, that in the second half of the first ½ hour, the decline in performance may have been similar to that of the second ½ hour (and the subsequent ½ hours).

Interestingly, Griffiths (personal communication with the reviewer) stated that when he conducted lifeguard surveys in the 1990s (reported in Parks and Recreation 1997 and Aquatics International 2000), he asked [mostly pool] lifeguards when they thought it was best for them to rotate [from one station to another]. According to Griffiths, “Sooner the better was a common response but 20 minutes was the preferred time.” Interestingly, this timing seems quite consistent with the Mackworth results. It is important to note however, that the reference is to rotating from station to station at a pool, which does not offer a break, per se, but rather a change of locale. This may be practical in a pool environment, but more difficult at an ocean beach (due to distance, etc.).

In a more recent study to that of Mackworth, Molloy and Parasuraman (1996) studied the effects of automation and reliance thereupon in cases such as pilots, who are assigned certain manual tasks and must rely on automation, but must also occasionally check to ensure that the automation is working properly. They assigned subjects to a 30-minute session during which a single automation failure event was to be detected. They found, in part, that over a 30-minute session, vigilance declined. In one example, this declined from over 60% of subjects recognizing an event to less than 20% recognizing the event.
Importantly, with respect to the subject at hand in this review, Molloy and Parasuraman noted that one of the most oft-voiced criticisms of laboratory vigilance research is, “… unrealistically high signal rates that do not reflect so-called real-world tasks. The present study used a signal rate of a single signal per [½ hour] session. The rate may still be lower for certain critical events found in real aviation environments …”

It is generally accepted that where there is high signal probability, the likelihood of detecting the signal is greater than where the time of the signal is uncertain. Signal events, or at least the most important signal event of drowning, for lifeguards can be expected to be much lower than those studied by Mackworth, or even Molloy and Parasuraman. However, lifeguards are expected to observe and respond to less-critical events during their watch, such as rule violations, and to respond to them. This presumably increases stimulation and may have a beneficial effect on vigilance.

Broadbent (1964) noted that in the absence of actual signals, artificial signals can enhance vigilance. In effect, the stimulus to lifeguards provided by less critical “signals,” such as rule violations, may have a similar effect. In any case, lifeguards are somewhat unlike study subjects asked to observe a single, specific event, although they are expected to prioritize the key event: a person in danger or potential danger, and to react immediately. That happens quite infrequently, but “missing” such a signal can have catastrophic consequences.

Donderi (1994) studied a situation more directly analogous to lifeguards. These were watchkeepers aboard ships, assigned to look for life rafts during one-hour shifts. He found that 55% of the life rafts were detected during the first half hour and 45% during the second half hour. Assuming that a half-hour watch would replicate the first half hour of the vigilance decrement results, 10% more life rafts would be detected with half-hour than with one hour watches. Unfortunately, Donderi did not report during which part of the first ½ hour the vigilance declined (or if it was a linear decline). For reasons noted in discussion of the Mackworth study, it may be that during the first 15 minutes, detection was high, then declined substantially in the second 15 minutes. Nevertheless, the average decline in vigilance from the first ½ hour to the second is roughly analogous to that reported by Mackworth.

In a study of 30-minute observation periods, Levine, et al., found that, “Dwell time, number, and accuracy of fixations on target objects decreased with time on task, and inaccurate scan-paths were often associated with performance errors.” Becker et al. (1995), found, in experiments involving a 40-minute watch, that, “perceptual sensitivity declined over the course of the watch.”

Since all of the studies tend to reinforce the concept that over time, vigilance declines, it can be reasonably posited that, within reason, the shorter the water surveillance assignment, the higher the level of vigilance; but an aspect of the responsibility of lifeguards intrudes into this conclusion. Lifeguards assigned to monitor an area are expected to be attuned to the behaviors and apparent skills of people in the area under surveillance, to aid in detection of distress or potential distress. As well, in the surf environment, recognition of the variable presence of rip currents (attributed to over 80% of rescues) and other hazards has value. Turnover of lifeguards watching the water causes a resetting of the familiarity of the lifeguard assigned to water surveillance with ambient conditions (both human and environmental) to a lesser state. Loss of
this familiarity would seem to lessen the ability and speed of detection of the need for lifeguard intervention.

Donald (2001) noted in his overview of vigilance, “Deciding on the work periods that will provide optimal vigilance within the shift will depend upon the reconciliation of four main factors. These are optimal concentration time, required viewing consistency, handover and work variety. The optimal concentration span that emerges from research and actual operations for a person is generally seen to be about 25 to 30 minutes, although some parties see it being as short as 20 minutes. However, concentration needs to be reconciled against the need for consistency of observation … Handovers which require more extensive briefing and familiarization in order to generate appropriate situation awareness, such as air traffic controllers, are less conducive to short work periods.” Lifeguard watches clearly require handovers that can be considered critical, perhaps similar to that of an aircraft controller. The lifeguard on watch has a history with the people and hazards under observation. A new lifeguard needs to garner such history by a verbal briefing (if provided) and experience, which will take time. Hence, limiting the amount of time lifeguards are assigned to watch the water too severely could have an overall effect opposite to that desired.

Of course, the value of familiarity with ambient conditions could be assumed, at some point, to be overcome by the decline of vigilance over time that is a hallmark of all vigilance studies. Absent research on this point, it is impossible to state, with certainty, what the optimum time would be at which the value of familiarity with ambient conditions is negated by the vigilance decrement (and whether familiarity can adequately be ensured through a proper handoff of responsibility from one lifeguard to another).

With respect to turnover of lifeguards on watch, during unscientific investigations of drowning deaths in lifeguarded areas in San Diego (surf lifeguards) by the author of this review and his agency, it was found that a disproportionate number appeared to occur just after a lifeguard had been relieved from water surveillance duties and a new lifeguard was so assigned. At the time, there was no policy requiring an overlap of observation by the lifeguard on watch and the lifeguard assuming watch, during which a briefing was to be held. It was surmised that lack of familiarity with the conditions and patrons by the lifeguard assuming watch (and perhaps distraction during the transfer) was a contributing factor to the drowning deaths. Whether this could prove out in scientific studies is unknown, but the remedial action was to require an overlap period, whereby the lifeguard leaving surveillance duties and the lifeguard assuming watch (and perhaps distraction during the transfer) would observe (and converse about conditions) together for about five minutes to ensure a knowing handoff. The results were not carefully studied, but believe to be beneficial. This agency experiences a typically rare drowning death rate in guarded areas roughly equivalent to the USLA standard of 1:18 million visitors, so evaluating the success of this policy is problematic. Nevertheless, there seems little to argue against the value of a handoff that involves an appropriate briefing, as against one that is the equivalent of a relay baton handoff.

The American Red Cross, the United States Lifesaving Association, and the YMCA of the USA all recommend that lifeguards be assigned to water observation for no more than one hour at a time. Based on the present state of research on the matter, this appears to be based completely upon expert opinion emanating from these organizations, which is nevertheless consistent. While
these three organizations appear not to have conducted research on the efficacy of this recommendation, they appear for the time being to be comfortable with it, presumably due to a sense of positive outcome (or the lack of a perceived negative outcome).

Finally, a study by Washburn, et al. (2004), for airport screeners, suggests that there may be significant variability among individuals for tasks that involve extended vigilance. While averages may suggest particular approaches, Washburn suggests that testing of individuals for the ability to maintain attention over long periods may help screen for the most capable employees. This seems to be a real possibility for lifeguard selection, which is presently not being applied under any known selection process. For example, by assigning lifeguard candidates to submit to a test of sustained attention span, employers could screen out prospective employees who fall below a set level of ability. Doing so would potentially improve outcomes substantially.

**Breaks**

The only study found that directly addressed the issue of breaks was that of Mackworth (1948), who found that when subjects were given a ½ hour break between two ½ hour periods of vigilance testing, their level of vigilance was fully restored. While not duplicated, no contradictory study was found.

**Feedback and Supervision**

Various researchers, including Mackworth (1948) have found that feedback and encouragement can beneficially impact vigilance (lessen the vigilance decrement). Schwebel et al. (2007) found that giving a mid-summer-season pep-talk to pool lifeguards regarding the importance of vigilance, negative consequences of failure, and tips on scanning improved overall vigilance, as well as patron behavior.

Supervision in particular was found by Putz (1975) to have a beneficial effect. In a study of 48 randomly selected female college students, he found that when subjects knew or even believed they were being monitored, their vigilance decrement decreased (i.e., they were less likely to miss signals). The best outcomes occurred when an experimenter was sitting in the same room as the subject or the subject was monitored by a closed circuit camera viewed by the experimenter, whose workings were known to the subject. In the first instance, missed signals increased from 13.8% in the first ½ hour to 20.1% in the third ½ hour. In the second instance, missed signals increased from 15.2% in the first ½ hour to 17.3% in the third ½ hour. The average in both cases was 16.8% missed signals. This is far better than the decrement in the Mackworth studies and suggests that supervision can dramatically lessen the vigilance decrement.

Griffiths (2001), while citing no specific research on the subject, recommended that supervisors check the performance of lifeguards once every 30 minutes, providing “constant encouragement” while doing so, to help ensure lifeguard vigilance. He recommended that they be checked to ensure that their behavior included: positioned properly, appropriately dressed, attentive, systematically scanning, and not engaged in social talking. He encouraged positive feedback, similar to that suggested by Mackworth.
Age

Should age be a compensating factor when considering the length of time a person can watch the water without a break? Findings vary, but there seems no strong evidence to suggest that persons of a given age group are more or less able to maintain vigilance. For example, Bunce (2002) sought to determine whether younger and older individuals perceive different levels of workload during the course of a vigil, and how those perceptions relate to actual performance on a vigilance task. In a review of existing literature, he found evidence that, as demands on attentional resources increase, so do age differences in vigilance performance, although most of the research dealing with samples of working ages show minimal age variation in performance. His study found, in his sample of working ages, that age differences do not exist in the ability to maintain a vigil, but that age differences do exist in respect to the perceived workload reported across that vigil. Essentially, age differences do not appear play a clear role in vigilance.

Sleep Deprivation

Deaconson et al. (1988) found no reduction in performance as a result of sleep deprivation in medical residents when they had less than four hours of sleep. This seems, however, to have been contradicted by many other studies. As Kendall et al. (2005) report, “Normal, healthy individuals need adequate sleep for optimal cognitive functioning (Himashree et al., 2002). Without adequate sleep, humans show reduced alertness (Penctar et al., 1993) and impairments in cognitive performance (Thomas et al., 2000, 2003).” Independently, Kendall et al. found that, “Sleep loss temporarily impairs vigilance and sustained attention.”

Williamson and Feyer (2000) found that sleep deprivation caused effects similar to alcohol intoxication: “After 17-19 hours without sleep, corresponding to 2230 and 0100, performance on some tests was equivalent or worse than that at a [blood alcohol content] of 0.05%. Response speeds were up to 50% slower for some tests and accuracy measures were significantly poorer than at this level of alcohol. After longer periods without sleep, performance reached levels equivalent to the maximum alcohol dose given to subjects (BAC of 0.1%).” They suggested that, “… people who have had 18 hours or longer without sleep are kept from at-risk behaviors such as driving, piloting aircraft, or operating machinery.” Apparently, it is not easy to recover from an “all-nighter.” Wilkinson (1963) studied soldiers who stayed awake all of one night, then received a full night’s sleep the next. Subsequent to this, he found that the lingering effects of the prior night’s wakefulness had a lingering, negative impact on vigilance.

Noise

Lifeguards may be exposed to a variety of noise. Azrin (1958) concluded that, “…it would appear that, at best, noise produces behavioral changes which are slight or transitory in duration. Much more typical is the almost complete absence of behavioral change as a function of the presence of intense noise.” Taylor (2004) found that simple noise alone (e.g., banging) under 80 dBA does not seem to have a marked effect on vigilance. Conversely, Becker, et al. (1995), found that noise did indeed have a decrement effect on vigilance. It would therefore seem possible, but uncertain as to whether reducing general background noise could beneficially
impact the vigilance decrement. More complex background noise (e.g., a news show on the radio) may have a different impact, but no studies were found on this subject. Therefore, the question of whether listening to the radio or music would enhance or hinder lifeguard vigilance was not addressed. It would seem that limiting ambient noise would not have a negative impact and may have a positive impact with respect to how long a lifeguard can remain attentive during a watch period.

**Temperature**

Lifeguards typically work in warm environments. An overview of vigilance research by Ballard (1996) cites studies by Hancock (1984) and Hancock and Warm (1989) stating that, in general, gradual exposure to temperatures greater than 32º Celsius [89.6º Fahrenheit] impairs vigilance performance, as measured both by error rates and the decrement slope, while sudden entry into the hot environment may [temporarily] facilitate performance. Wyon et al. (1996) found that driver vigilance was significantly lower when motor vehicle compartment temperature was maintained at 27º C [80.6º F], in comparison with 21º C [69.8º F], when subjects who were randomly assigned to these two conditions drove on the public road for 60 min. The negative effects of raised compartment temperature on vigilance were more marked in the second half-hour and at speeds below 60 km/h, i.e., in city traffic, in comparison with driving on the open road. Froom et al. (1993) found, in a study of 500 Israeli military helicopter accidents, that pilot errors were least at temperatures of 25–29 C, higher at 30–34 C, and highest at 35 C.

These studies suggest that any recommendations regarding the optimal period during which lifeguards should be continually assigned to water observation, based on experiments at room temperature or similar, should specify that as temperature increases, the optimal period should decrease.

**Drugs and Alcohol**

Damos and Parker (1994) found that people assigned to a vigilance task who tested positive for recreational drugs (including marijuana, cocaine, opiates, benzodiazepines, or a combination of marijuana and cocaine) were more likely to demonstrate a high false alarm rate than were those who tested drug negative. Other studies appear to indicate that regardless of actual intoxication rates, vigilance is lower in regular users of certain recreational drugs.

**Caffeine and Sugar Stimulants**

Childs and de Wit (2006) attempted to determine the effects of caffeine on performance. In doing so, they evaluated the effects on people who were not habitual caffeine users. They found that there was an enhancement of vigilance, but that in high doses, there was also an increase in anxiety. They concluded that, “… caffeine, at doses found in commonly consumed beverages, produces net beneficial mood and performance-enhancing effects in light, nondependent users.” Zwyghuizen-Doorenbos et al. (1990) found that caffeine improved alertness and vigilance. Jarvis (1992) found that even for habitual users of caffeine, consumption produced benefits to cognitive performance, and that higher daily caffeine consumers tend to perform somewhat better than to low consumers. Mackworth (1948) found that, “… if [subjects took] 10 mgms of amphetamine
sulphate by mouth one hour before the start of the test … [their performance stayed] at the initial high level of accuracy throughout the two-hour spell.”

Anderson et al. (2006) found that energy drinks containing sugar, but little caffeine, have a negative longitudinal impact on vigilance. Only ten subjects were studied. The indication was that sugar may provide a temporary boost (which is well documented), but the ensuing decline is significant and outweighs the benefits for a long-term vigilance task.

Considering that many lifeguards are in their teens or early twenties, when hard partying is considered to be more typical behaviorally and lack of sleep may be more likely, information on the relative benefits of caffeine and the relative detriments of sugar may be valuable. This may be of particular value considering the popularity of energy drinks and the like.

Circadian Rhythms

A variety of researchers have tried to identify the effects of circadian rhythms on sleepiness and alertness/vigilance. Mavjee and Horne (1994) referenced prior studies that conflict on this issue and note that a variety of factors may result in dips in alertness during mid-afternoon, such as boredom and sleepiness. It appears that there is lack of agreement among studies on the issue of circadian rhythms and that this is therefore not an issue around which lifeguard assignments should be designed. However, since many studies note a dip in alertness, for whatever reason, in the afternoon, it may be useful to note this in lifeguard training and to recommend actions that might help avoid the problem, such as consumption of caffeinated drinks that do not contain sugar.

Sleep Apnea

People with sleep apnea are known to sleep poorly. Mazza et al. (2005) found that, “When using an adequate panel of vigilance tests to assess the ability to remain awake, and to maintain selective, sustained and divided attention, a large majority of sleep apnea patients demonstrated attention defects.” In this context, people with sleep apnea may perform poorly as lifeguards relative to the general population. Lifeguard employers may wish to screen for this condition, as appropriate.

Preliminary Brief Evidence Summary and Guideline Document Section:

A comprehensive overview of the following, with references, can be found in the foregoing section.

All studies on vigilance that were reviewed agree that vigilance typically declines over time on task, although none meaningfully identified a specific, magic time period during which vigilance was good, then turned bad. Results from a number of studies suggest that after 15–20 minutes, vigilance declines more significantly than later in a vigilance task, although no study simulated circumstances directly analogous to a lifeguard at a pool or beach environment, addressed the very low signal event occurrence for lifeguards, or directly addressed the potential negative impact of rapid turnover of people assigned to surveillance in a lifeguard-like setting. Because of
the differences in a laboratory setting and a lifeguard environment, it is not, in the reviewer’s opinion, possible to identify an ideal time period, based on existing research. In a pool environment, where lifeguards are observing a similar area (where a handoff briefing need not be too detailed), and where a bump system can be used to move people from station to station, there may be value in trying to do so every 20 minutes, but this is pure speculation. Thus, no recommendation is made.

Research does identify the following:

1) After a ½ hour break, subjects in the only study identified on the matter of breaks were returned to their original level of vigilance. It may be possible that shorter breaks would have the same effect, but studies on this issue were not identified.

2) Regular feedback and supervision can very positively impact vigilance.

3) Sleep deprivation negatively impacts vigilance.

4) Ambient temperatures above levels considered normally comfortable negatively impact vigilance at an increasing rate (as temperature increases).

5) Chronic drug users have difficulties maintaining vigilance.

6) Consumption of caffeine positively impacts vigilance.

7) Consumption of sugar negatively impacts long-term vigilance.

8) People with sleep apnea have substantial difficulties maintaining vigilance.

**Recommendations and Strength (using table below):**

**Standards:**

1) Breaks between water observation assignments should be no less than 30 minutes in length.

2) Lifeguard supervisors and managers should be encouraged to maintain an on-site presence and to provide regular encouragement during each 30-minute period of watch to lifeguards assigned to surveillance, as this has been shown to positively affect vigilance.

3) Lifeguard management should hold occasional meetings to discuss the importance of the lifeguard function, the negative outcomes of error, and ways to improve performance.

4) Lifeguard employers should take reasonable steps to protect lifeguards on watch from temperatures above 70 degrees and consider reducing the length of watches when this is not possible. Use of air-conditioned lifeguard towers should be considered where feasible, along with sun protection for outdoor activities (sun shades, protective clothing,
etc.) Indoor temperatures at pools should be adjusted in a manner aimed at enhancing lifeguard vigilance.

5) Lifeguard training should emphasize the negative impacts of sleep deprivation on vigilance and performance to encourage lifeguards to get a full night’s sleep before each day of vigilance work.

6) Lifeguard training should emphasize that use of recreational drugs can negatively impact vigilance, even after the apparent effects have worn off.

7) Lifeguard training should include information regarding the beneficial affect of low level consumption of caffeine in non-sugared drinks on vigilance.

8) Lifeguard training should discourage the use of high-energy and other high-sugar drinks.

**Guidelines:**

1) Lifeguard employers should consider random drug testing.

2) Lifeguard employers should avoid hiring people known to suffer from sleep apnea.

**Options:**

**No Recommendations:**

Guideline Definitions for Evidence-Based Statements

<table>
<thead>
<tr>
<th>Statement</th>
<th>Definition</th>
<th>Implication</th>
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<tbody>
<tr>
<td><strong>Standard</strong></td>
<td>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.</td>
<td>One should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.</td>
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<tr>
<td><strong>Guideline</strong></td>
<td>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 strongly outweigh the harms.</td>
<td>One would be prudent to follow a recommendation but should remain alert to new information.</td>
</tr>
<tr>
<td><strong>Option</strong></td>
<td><strong>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.</strong></td>
<td><strong>One should consider the option in their decision-making.</strong></td>
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<tr>
<td><strong>No recommendation</strong></td>
<td><strong>No recommendation indicates that there is a lack of pertinent evidence and that the anticipated balance of benefits and harms is presently unclear.</strong></td>
<td><strong>One should be alert to new published evidence that clarifies the balance of benefit versus harm.</strong></td>
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Unites States Lifeguarding Standard Coalition
Scientific Review Form

Author: Linda Quan, MD
Organization Representing: University of Washington School of Medicine

Question: How long should a lifeguard be assigned to continually watch the water before interruption of duty?
Date Submitted: May 17 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: How long should a lifeguard be assigned to continually watch the water before taking a break?

Revised to: Should a lifeguard be assigned to continually watch the water for more than 30 minutes without a break?

Introduction/Background:
Provide any relevant background on the subject and the need to address this question.
How long a lifeguard should be assigned to watching the water for drowning or predrowning activity has not been defined. Many settings limit the watch to 1 hour. Factors affecting efficacy or ability to perform the task include personnel characteristics, physical surroundings, and time. Time has been one controllable factor. The evidence behind the question is based on the likelihood of fatigue and boredom affecting ability to stay on task.

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.
I submitted to research librarians at the Children's Hospital and Regional Medical Center and at the Health Sciences library at the University of Washington a request for literature on vigilance. I searched articles by authors who had done more than one study or a very relevant study on the topic.
I searched PubMed myself.
I received some articles from Chris Brewster’s search.
### 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)*

<table>
<thead>
<tr>
<th>Author(s) and Year published</th>
<th>Full reference</th>
<th>Summary of Article (if abstract available, first past abstract and then provide your summary)</th>
<th>Level of Evidence (Using table below)</th>
</tr>
</thead>
</table>
| 1. Mollow R, Parasuraman R. Monitoring an automated system for a single failure: vigilance and task complexity effects. Human Factors 1996;38:311-322. | Abstract: Examined the effects of task complexity and time on task on the monitoring of a single automation failure during performance of a complex flight simulation task. 36 18-38 yr old students participated in 1 of 3 groups: (1) simultaneous performance of all 3 flight simulation tasks (multicomplex task), (2) performance of the monitoring task (single-complex task), or (3) performance of a simple visual vigilance task (simple task). For the multicomplex task, monitoring for a single automation control failure was poorer than monitoring engine malfunctions under manual control. A vigilance decrement in detecting the automation failure over time was found both for the multicomplex and the simple visual discrimination tasks, while Ss in the single-complex condition detected the automation failure equally well over time. Implications for theories of vigilance and automation design are discussed. (PsycINFO Database Record) | Quan’s abstract summary:  
Study question: Does vigilance decrease over time for (rare) single events in both simple and complex tasks?  
Study design: Experimental study, randomized to simple or complex (flight simulation) tasks  
Method: Adults (ages 21-38 yo) were randomized to perform a simple manual, simple-complex or a multicomplex visual task on a computer during which they were were presented a single critical visual signal either in the first 10 minutes or the last 10 minutes of the 30 minute sessions. Outcome measure: detection of the critical signal.  
Results: Performance decreased with more complex (other) manual tasks, and with time. Conclusions: vigilance declines when tasks are more complex; too much or too little to do can reduce vigilance. Decrement is worse with very low rates. Vigilance decreases over a thirty minute duration on task.  
Comments: although this is a computer simulation study in a very controlled environment, it supports the negative effects of time and multitasking on vigilance. Vigilance decreases within a 30 minute period.  
*Level of evidence: 1 B* |  |

Abstract: 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 Ss (aged 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 (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. (PsycINFO Database Record)

Quan’s abstract
Study question: what is the effect of time and auditory stimuli on frequent visual scanning (vigilance)?
Method: Corneal-reflection computerized system measured eye movements in 20 subjects visually scanning a computer monitor that had sets of digits displayed. Visual scanning job was to watch for specific, infrequent signal arrays among a set of digits over a 30 minute period. Then subject had to intervene by bar press (outcome measure). Noise stimuli was intermittent sound-bursts; Control stimuli was white noise. Outcome measurements were subjective fatigue ratings, number of fixations on target, distance of fixations from target digits, duration of fixations on target, and performance evaluation of correct hits, misses, an false alarms, too quick a response using the bar press. They also evaluated outcomes by gender and time periods within the 30 minute session.
Results: Over the 30 minute session, Dwell time per event and number of fixations on target declined linearly with time. Fatigue increased. Sound bursts increased off-target scanning. Gender had no effect.
Conclusions: over time, the amount of time and number of scans decreased. However this could reflect increasing efficiency of the cognitive process so that shorter dwell time might not be a bad thing. Intermittent noises may enhance vigilance.
Comments: Time/fatigue decrease vigilance. Misses are caused by errors in visual scanning and in cognitive processing. Both sensory and cognitive processes contribute to vigilance. Sound stimulation disrupted scanning. This study used a very cool tool to evaluate scanning. The complexity of the cognitive piece comes closer to mimicking the lifeguard setting than most studies testing scanning on a computer for less complex items.
Level of evidence:  2

Abstract: A total of 83 drivers, 51 males and 32 females, aged 25-65, were recruited to drive an apparently unmodified passenger car for 1 h over at least four laps of a
predetermined route on public roads, which included seven sets of traffic lights and sections limited to 50, 70, 90, and 110 km/hr. They were randomly assigned to one of two thermal conditions (21 or 27 degrees C) and drove only during the hours of daylight. A computer initiated unprepared signals to which drivers would normally be alert. Drivers responded by pressing a foot-switch and reporting verbally. Signals were selected at random from 21 possible signals and were presented for up to 3 min., with a random delay of 30-180 s after each response or failure to respond. The negative effect of heat stress on vigilance was statistically significant. At 27 degrees C, the overall proportion of missed signals was 50% higher and response times were 22% longer than they were at 21 degrees C. These effects of heat were significant and proportionally greater in the second half-hour, for subjects <40 years and for speeds below 60 km/h. The latter findings suggest that heat may have increased arousal and there was some indication of a redistribution of attention away from the most peripheral signals at the higher temperature. Overt driving errors were observed significantly more often at 27 degrees C than at 21 degrees C for women only.

Quan’s comments: Very nice study, well thought out, terrific methodology, and practical. Also supports that > 26 degrees C affects performance. Shows performance worsens with increasing time on task > 30 min too under warm conditions.

*Level of evidence 2*


Study design: Review of literature of factors affecting vigilance and extrapolation of the data to lifeguard settings.

Quan’s comments: Provides multiple references to degradation of vigilance in time. Suggests that breaks increase performance by alternating activities.

Comment: superbly organized. Should be a model for this project.

*Level of evidence: 4*


Quan’s abstract

Study question: Review what is known about vigilance in general

Study design: NA.

Summary:

Workload Factors which decrease vigilance:
- boredom, monotony (operator underload);
- fatigue, tiredness;
- difficulty with “displays”
- operator overload

Work complexity factors
- Tasks requiring appraisal and judgement (cognitive processing)
- Successive tasks
Background noise (increases distraction)  
Level of workload  
Work periods  
  Optimal concentration span in 25-30 minutes  
  Intense visual analysis increases fatigue  
  Doing a variety of tasks decreases boredom  
Signal characteristics  
Consistency of the signal- the rarer the signal (event) the lower the vigilance, greater the decrement in vigilance  
Signal predictability  
  Low incidence rate demotivates  
  Not knowing where the signal will come from lowers detection  
Signal distinctiveness  
  Position of the signal in line of sight  
  Subtle signal  
  Background noise  
  Cry wolf  
Signal interpretation  
  Signals that are memorized are better recognized; those requiring interpretation have increased response time and less detection  
Shift/sleep  
Work environment  
  Lighting  
  Noise- higher noise levels, vibrations  
  Ventilation  
  Temperature- ideally 20-26 degrees with decreased performance at extremes  
  Humidity  
Worker characteristics  
  Visual, audio, color acuity, processing, observation skills, attention  
Management enhancement methods  
  Work schedules  
  Rest schedules  
  Simulated incidents- provide feedback,  
  Use personnel selection procedures to select for vigilance capabilities  

Comments: this is a superb article. Although it primarily references studies in the airline industry (traffic controllers, luggage scanners) it is practical and provides a framework to the approach and solutions to the problem.

Level of evidence: 5

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1a</td>
<td>Population based studies, randomized prospective studies</td>
</tr>
<tr>
<td>Level 1b</td>
<td>Large non-population based epidemiological studies, meta-analysis or small randomized prospective studies</td>
</tr>
<tr>
<td>Level 2</td>
<td>Prospective Studies which can include, controlled, non-randomized, epidemiological, cohort or case-control studies</td>
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<tr>
<td>Level 3a</td>
<td>Historic which can include epidemiological, non-randomized, cohort or case-control studies</td>
</tr>
<tr>
<td>Level 3b</td>
<td>Case series: subjects compiled in serial fashion without control group, convenience sample, epidemiological studies, observational studies</td>
</tr>
<tr>
<td>Level 3c</td>
<td>Mannequin, animal studies or mechanical model studies</td>
</tr>
<tr>
<td>Level 4</td>
<td>Peer-reviewed works which include state of the art articles, review articles, organizational statements or guidelines, editorials, or consensus statements</td>
</tr>
<tr>
<td>Level 5</td>
<td>Non-peer reviewed published opinions, such as textbooks, official organizational publications, guidelines and policy statements and consensus statements</td>
</tr>
<tr>
<td>Level 6</td>
<td>Common practices accepted before evidence-based guidelines or common sense</td>
</tr>
<tr>
<td>Level 1-6E</td>
<td>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.</td>
</tr>
</tbody>
</table>
Summary Table of Evidence
Place all the evidence listed in the previous sections in one of the following three columns using the follow approach:
37. Place each article or report in one of the columns and in its own row
38. List articles with highest level of evidence first
39. In box place name of lead author and in parenthesis year published
40. 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)

<table>
<thead>
<tr>
<th>Supportive of Recommendation</th>
<th>Opposing Recommendation</th>
<th>No Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mollow (1996)                             LOE 1 b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavine (2002)                                LOE 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wyon (1996)                                  LOE 2</td>
<td></td>
<td></td>
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<tr>
<td>Applied Anthropology (2001)       LOE 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Donald (2001)                               LOE 5</td>
<td></td>
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</tr>
</tbody>
</table>

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

Degradation of vigilance over 30 minutes is documented in multiple experimental settings and is generally accepted by other disciplines/work settings. It has not been assessed in the lifeguarding setting. If these degradations do occur in the lifeguarding setting, their actual effect is not defined, ie as to whether the amount of degradation is really significant, “clinically significant”.
Preliminary Guideline Document Section:
Please provide a brief summary of the evidence from the previous section using the template language below and summarize the recommendation also using the template language. Then place each of the recommendations in the table at the end. Descriptions of how to determine the strength of the recommendations are listed below.

Evidence from one randomized experimental study (LOE 1 b) and two controlled studies (LOE 2) of noise and another on ambient temperature, scanning performance decreased significantly when adults’ duration of scanning was > 30 minutes in computerized settings to driving vehicles.

There is expert opinion and consensus that optimal concentration span is 25-30 minutes.

Therefore, it is recommended to make a recommendation for limiting scanning periods without a break at either pools or beaches by lifeguards to 30 minutes as a guideline.

Recommendations and Strength (using table below):

 Standards:

 Guidelines: Lifeguard scanning the pool is maximal for the first 30 minutes on duty. When risk is higher due to the presence of other risk factors, ie, large numbers of swimmers, noise, heat, lifeguard fatigue, scanning duty should be limited to 30 minutes followed by a break involving physical activity.

 Options:

 No Recommendations:

 Guideline Definitions for Evidence-Based Statements

<table>
<thead>
<tr>
<th>Statement</th>
<th>Definition</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>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.</td>
<td>One should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.</td>
</tr>
<tr>
<td>Guideline</td>
<td>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</td>
<td>One would be prudent to follow a recommendation but should remain alert to new information.</td>
</tr>
</tbody>
</table>
impossible to obtain but the anticipated benefits outweigh the harms.

<table>
<thead>
<tr>
<th>Option</th>
<th>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.</th>
<th>One should consider the option in their decision-making.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No recommendation</td>
<td>No recommendation indicates that there is a lack of pertinent evidence and that the anticipated balance of benefits and harms is presently unclear.</td>
<td>One should be alert to new published evidence that clarifies the balance of benefit versus harm.</td>
</tr>
</tbody>
</table>

**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)*