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LIFEGUARD VIGILANCE

BIBLIOGRAPHIC STUDY

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1 - INTRODUCTION - OBJECTIVES

Drownings are a significant cause of mortality, particularly among young children. Within the context of public swimming pools, the lifeguard is the person who is most involved in the surveillance and maintaining of user safety. Active in an environment which is demanding on a sensory level, a lifeguard must constantly maintain a high degree of vigilance for the entire period while he/she is on duty. Computer-aided drowning detection equipment provides the lifeguard with precious assistance, since it can help to overcome the natural variations in human vigilance abilities. Nevertheless, these systems cannot totally replace lifeguards. In order to optimize the operation and means of usage of such devices, it is therefore critical to better understand the characteristics of vigilance and of performance. The aim of the bibliographical summary presented in this report is to provide an overview of the works in this field. As few studies have been carried out specifically on lifeguards, this document also presents the results of laboratory studies and from other professional domains where vigilance is a crucial performance and safety factor. The implications for lifeguard performance are pointed out on the basis of these results.

2 - A FEW STATISTICS

Drowning is a high cause of mortality, as it is estimated that there are 140,000 fatal drowning accidents per year throughout the world, i.e. a mortality rate of 3.5 per 100,000 people. In addition, it is considered that near-drownings are approximately 10 times as frequent as drownings. Approximately 10% of these near-drownings result in serious neurological consequences.

The most frequently cited drowning risk factors include:

- Age: children under the age of five are the most frequent victims, then adolescents from 14 to 19 years of age
- Sex: most victims are male
- Time of day: a study of 1000 cases (Urgence Pratique, 1995) indicates that 3:00 to 4:00 PM is the peak drowning time
- Place of drowning: children most often drown at home or in the immediate surroundings (private pools, baths), whereas adolescents most often drown in public swimming pools. For all age classes taken together, drownings in pools are nevertheless the most rare (approximately 7.4% of overall drownings), with the majority occurring in the sea.

These few statistics therefore indicate that pool drownings are, most fortunately, a relatively infrequent phenomenon, a fact which can contribute to the reduced vigilance of lifeguards.

3 - COGNITIVE AND PHYSIOLOGICAL ASPECTS OF VIGILANCE

In the scientific literature, the notion of vigilance covers two different aspects: a cognitive dimension and a physiological state which may not be superimposed on one another. It is often considered synonymous with attention or alertness level.

On a cognitive level, vigilance is defined as "the ability to detect unforeseeable and slightly suprathreshold signals" (Pieron, 1979). This definition limits vigilance to specific situations wherein a subject must monitor the appearance of critical signals. This can nevertheless be extrapolated to concrete activities such as the vigilance efforts required of lifeguards. The detection of a drowning person comes into play in the lifeguard's vigilance capacities and requires the performance of an appropriate action. The subject must use a certain amount of **attention** in order to employ this capacity for vigilance. This cognitive psychology notion describes "*a selective mental orientation which includes an increase in efficiency within a certain activity mode, with the inhibition of concurrent activities*".

Implications for Lifeguards: the lifeguard must restrict his/her attention from all non-relevant stimulations coming from the environment (for example: swimmers on the water's surface or below it, children's games and cries in the pool) in order to focus all perceptive and mental activities on relevant indications which identify a situation of distress or drowning.

The attention mobilization depends on how demanding the task is and on the subject's experience with this task. The experience level conditions the implemented attention type (Fisk and Schneider, 1981). When this level is low, the subject uses what are known as **controlled processes**, which require greater effort. These processes are often limited by short-term memory and do not allow the subject to share his/her attention between several sources of stimulus. Thus, a beginning driver uses controlled processes, which must account for each of the activities involved in the task of driving: putting on the seatbelt, changing gears, releasing the clutch. Each of these sub-activities requires most of the resources of a beginning driver, such that he/she has problems

carrying out two simultaneously actions. As a result of familiarity, the attention gradually shifts from controlled processes to **automatic processes**. These are quick, require little effort, and are not limited by short-term memory. They allow the subject to drive "automatically", while devoting his/her attention to the vehicle's exterior.

Experiments on vigilance were conducted using specific tasks which called on the subject to detect critical signals occurring infrequently or randomly. Historically, the first vigilance task was developed by Mackworth in 1950, at the request of the Royal Navy, which was concerned with the performance degradation of sonar operators called on to detect the presence of enemy submarines. This task used a clock where the second hand moved in successive jumps of one unit per second. At irregular intervals, the hand made a double jump, which was the critical signal the subject had to detect by pressing a button. The experiment lasted for two hours. The results (Figure #1) indicate that the percentage of omissions increases significantly after the first 30 minutes. This study, subsequently confirmed by many other studies, was the first to prove that the vigilance capacity **cannot be maintained at an optimum level for more than 30 minutes and that, from the start, maximum efficiency is never possible since 15% of the omissions already occur during the first 30 minutes.**

The performance of tasks of this type is also affected by the subject's physiological state. This physiological state or activation describes "the excitability of the central nervous system". The activation states are in a continuum ranging from deep sleep to states of strong emotion. Each of these physiological states has a corresponding performance level. Each level is characterised by specific electrophysiological manifestations, particularly on an electroencephalographic (EEG) level (Table 1). Figure #2 gives the EEG readings which correspond with these various states. EEG recordings are frequently used to assess the vigilance of operators as they carry out their tasks. This method was notably used to assess the alertness levels of train conductors (Coblentz and Cabon, 1994), automobile drivers on motorways (Cabon and coll., 1996) and of pilots on long-haul flights (Cabon and coll., 1993).

Figure #1

**Diminishing Function of Vigilance in the Mackworth Clock Test
(according to Mackworth, 1950)**

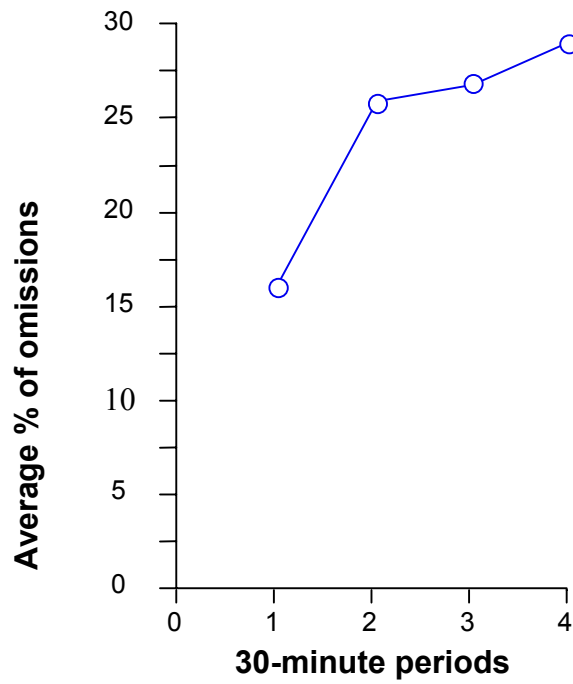


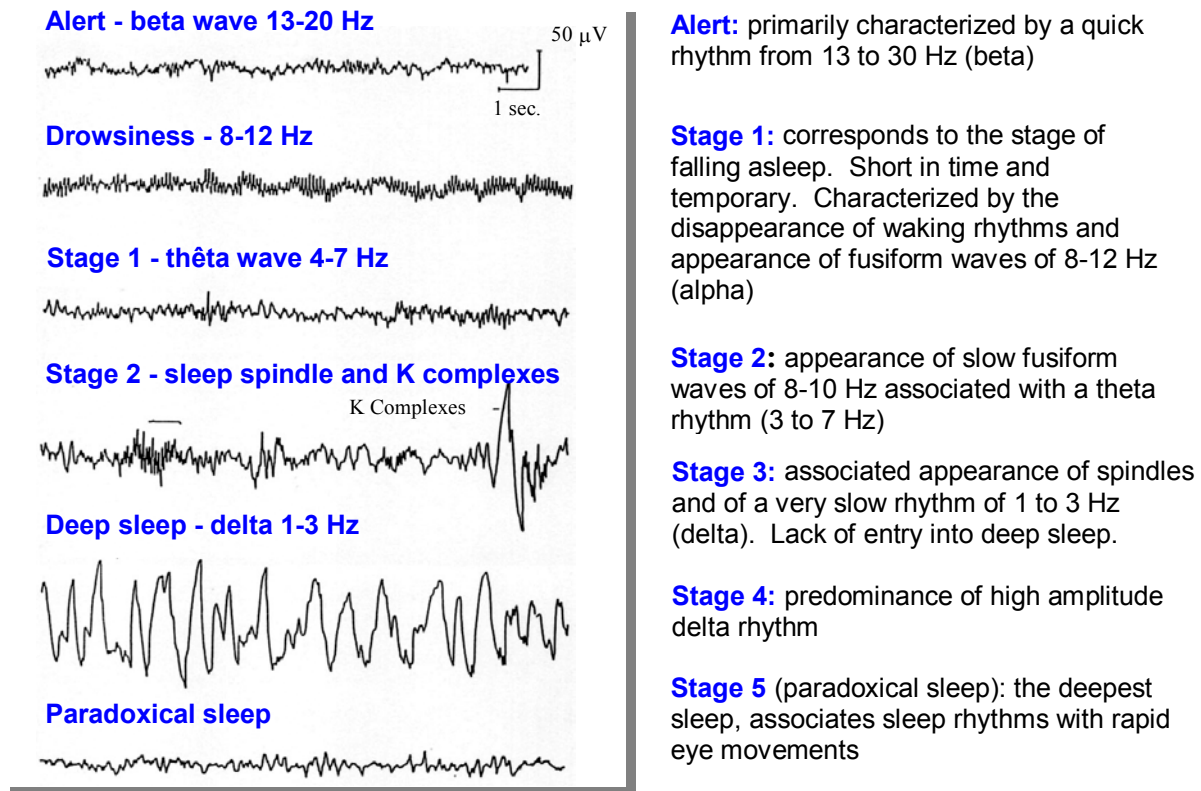
Table 1
Continuum in the Stages of Vigilance
(According to Defayolle, 1971)

Behavioral CONTINUUM	EEG	STATE OF VIGILANCE	EFFICIENCY
Intense emotion (fear, rage, anxiety)	Unsynchronized, low to moderate amplitude, rapid frequencies, low amplitude	Extreme alertness, dispersed or diffused attention (mental confusion)	Mediocre, loss of control, fright, disorganized behavior
Attentive alert	Partially synchronized, predominance of rapid low amplitude waves	Selective attention subject to variations, concentration, anticipation	Good (efficient, selective and rapid reactions) Behavior suited to response series
Relaxation	Synchronized: optimum alpha rhythm	Floating attention, not concentrated, promotes free associations	Good for routine reactions and creative thought
Drowsiness	Reduced alpha, slow intermittent low amplitude waves	Imperfect alertness, limited state, mental imagery, daydreaming	Mediocre, behavior not coordinated, unstable, loss of a sense of duration
Light sleep	Occasional peaks and broader slow waves, disappearance of the alpha	Notably reduced consciousness, dream state	Nil
Deep sleep	Broad and very slow waves, synchronized	Total disappearance of vigilance, loss of memory, stimulation or dreams	Nil

Of the six levels mentioned above, only one is efficient in the event of emergencies:

Figure #2

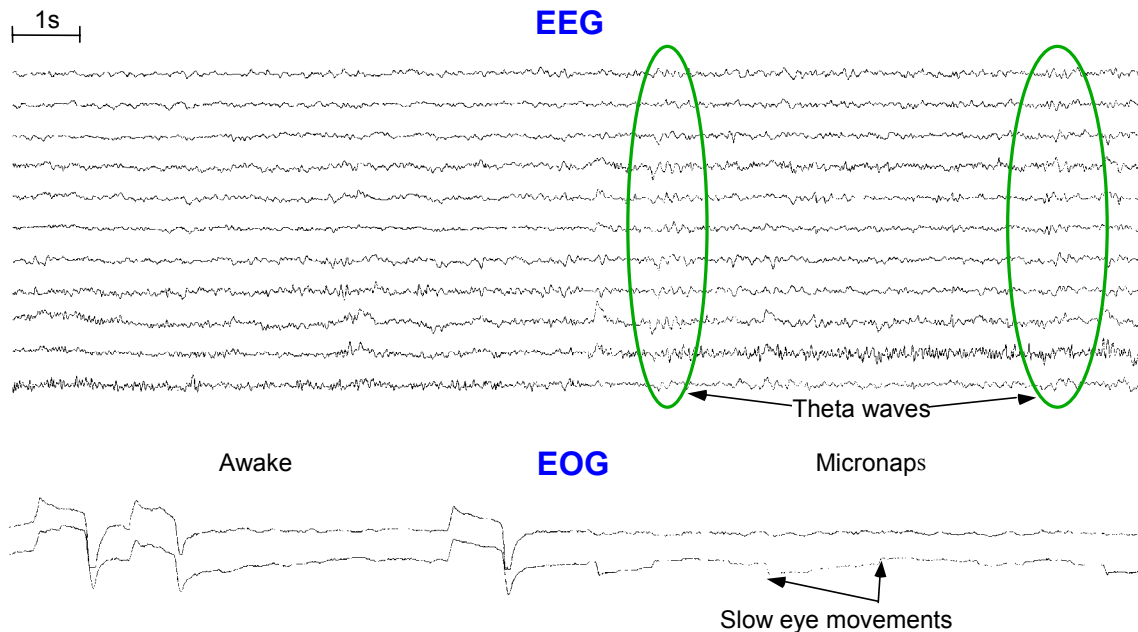
Example of Electroencephalograph Measurements Characteristic of the Various Stages of Sleep



The EEG brings to light the appearance of *micronaps*, i.e. short periods of sleep characterised by the occurrence of theta rhythms and slow eye movements (Figure #3). These episodes result in quick deterioration of driving performance. In this situation, the only truly efficient means to recover a satisfactory level of alertness is sleep, even for very short periods.

Figure #3

Occurrences of Micronaps During Motorway Driving (According to Cabon and coll., 1996)



For long-haul flight pilots, such occurrences have been observed even in descent phases (Cabon and coll., 1995). With automobile driving, these episodes primarily occur during night trips or in the event of serious sleep deprivation (Cabon and coll., 1996). The subject is aware of his/her state, and then generally stops to take a rest. In addition to these micronaps, other more moderate manifestations may occur, particularly when the driving is boring. These episodes of decreased vigilance, known as *hypovigilance*, result in an increased alpha rhythm on the EEG (Figure #4). Though resulting in few observable behavior modifications, they are generally associated with increased response times, which can be up to 50% of the values observed during an optimum state

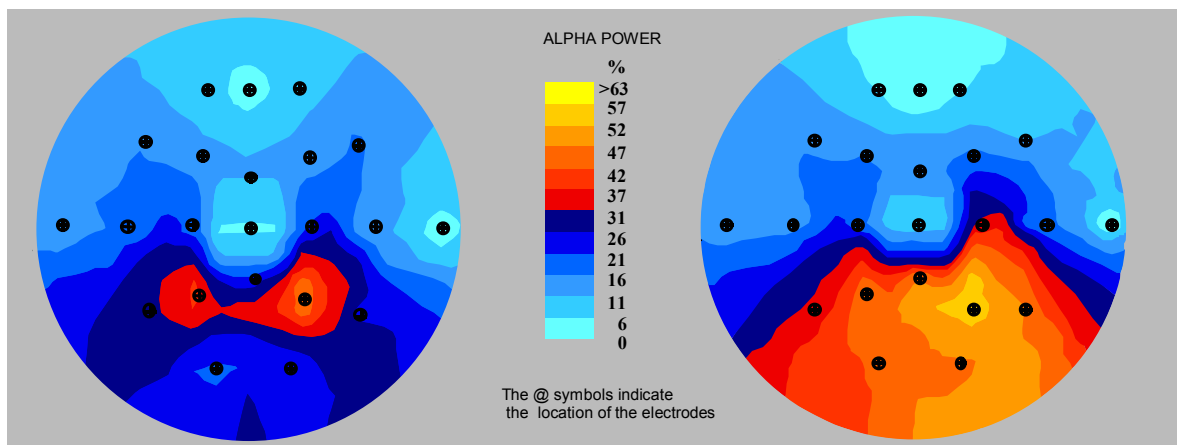
of vigilance. In most cases, the driver is unaware or only slightly aware of his/her state, which considerably increases the risks of accidents.

The relation between physiological activation and vigilance is not linear. To attain an optimum vigilance level, an optimum activation level is required: this is referred to as “attentively alert”. Either below or above this state, the vigilance is degraded. At the start of the 20th century, this relation was modelled by Yerkes and Dodson (1908) in the form of an inverted U curve (Figure #5). Originally obtained with animals, these results were then reproduced during experiments with man. The other dimension to this law has to do with the interaction between the task's difficulty and the activation level: the optimum activation level is lower for a difficult task than for an easy task. With a given increase in the alertness level, a difficult task will result in a faster drop in performance than an easy task.

Implications for Lifeguards: if the lifeguard is at a high alertness level (favorable time of day, consumption of caffeine), environmental factors (e.g.: noise) are likely to increase his/her alertness level beyond the optimum, which can result in lower performance. This reduced performance will occur quickly in a complex situation (e.g.: many swimmers in the pool, high noise level, etc.).

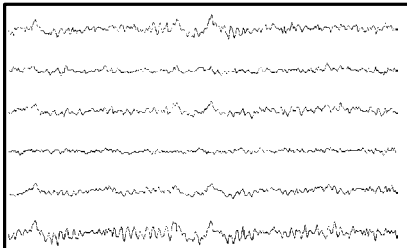
Figure #4

Representation of the Brain's Electric Activity (Mapping and Gross EEG) in a Driver (according to Cabon and coll., 1996)



State of attentive wakefulness

The state is characterized by low power in the frequency band of 8-12 Hz (alpha waves) on an electroencephalogram. The result is a predominance of primarily blue colours.



State of defused wakefulness (hypovigilance)

The state is characterized by high-power in the frequency band of 8-12 Hz (alpha waves) on an electroencephalogram. The result is a predominance of primarily yellow and orange colours in the occipital part of the brain.

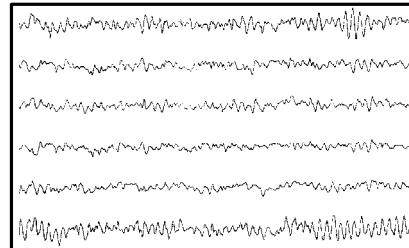
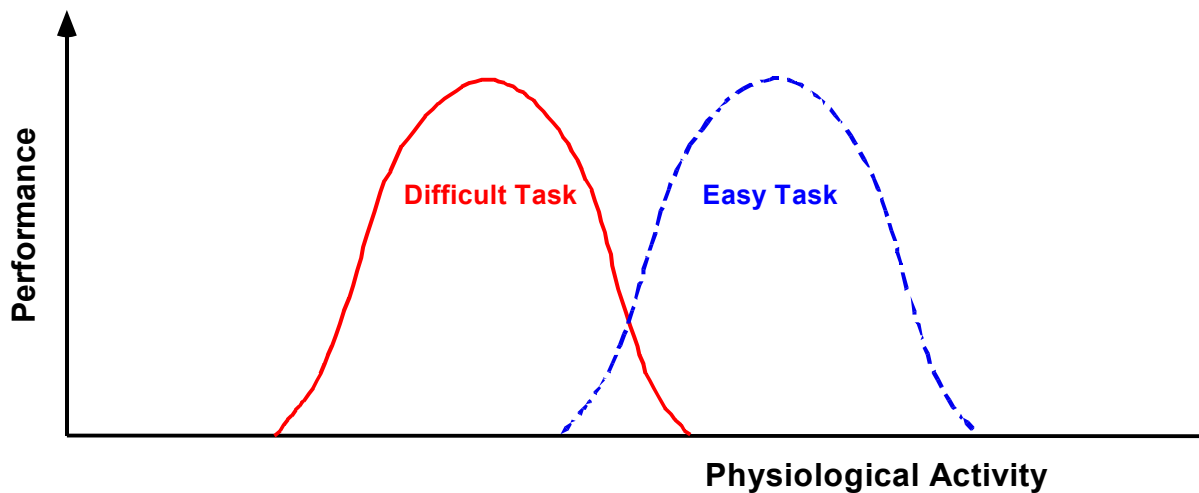


Figure #5

**Relation Between the Activation, the Task Difficulty
and the Performance**

(according to Yerkes and Dodson, 1908)



Other concepts are frequently associated with vigilance, particularly in studies dealing with the effects of automation on a human operator. Automation has globally enabled major safety improvements. However, these technological breakthroughs raise new questions. Automation, and by extension all situations wherein the operator is excessively assisted, result in a feeling of **marginalization** (Wiener and Curry, 1980, Norman and coll., 1988). The operator has the impression of being peripheral to the system, and of no longer occupying a central position. This feeling can result in a state of **complacency**, i.e. the operator's exaggerated confidence in the systems which he/she must control (Parasuraman, 1991).

Another consequence of automation, brought to light in the aeronautics field (Hughes, 1989), involves the move from a monotonous phase to a heavy workload phase. This move can result in a series of occurrences known as the **boredom-panic syndrome**, which is very detrimental to an operator's performance. In the automotive domain, it is probable that certain phases in the trip, and particularly unforeseen events, can result in occurrences of a similar nature. This notion must also be taken into account when designing a system to stimulate a driver's vigilance.

4 - FACTORS AFFECTING THE VIGILANCE LEVEL

The factors affecting the vigilance level have been the subject of many studies in order to define effective means to maintain the state of vigilance. These factors can be grouped into three categories:

- the task's characteristics,
- the physical surroundings,
- the temporal progress of the activity.

4.1 - The Task's Characteristics

The initial works on the task's characteristics dealt with the influence of the frequency of the critical signals (to be detected) and the non-critical ones (to be rejected) on the performance. In Figure #6, we see that the actual performances during a vigilance task improved when the number of critical signals increased. Conversely, the performance results were at their best when few non-critical signals were present (Figure #7). These two studies indicate that performance is higher in the presence of a high signal-noise ratio, which means that there is a strong proportion of relevant information and little irrelevant information.

Implications for Lifeguards: the presence of high volumes of irrelevant visual or auditory stimulus (non-critical signals) in the pool environment is a factor which contributes to reducing the vigilance of lifeguards. Conversely, drowning incidents with their associated signals are rare, and they occur only randomly. The **signal-noise ratio is thus very unfavorable to maintaining vigilance.**

Figure #6

Effect of the Probability of Critical Signals on the Response Time
(according to Jerison and Pickett, 1964)

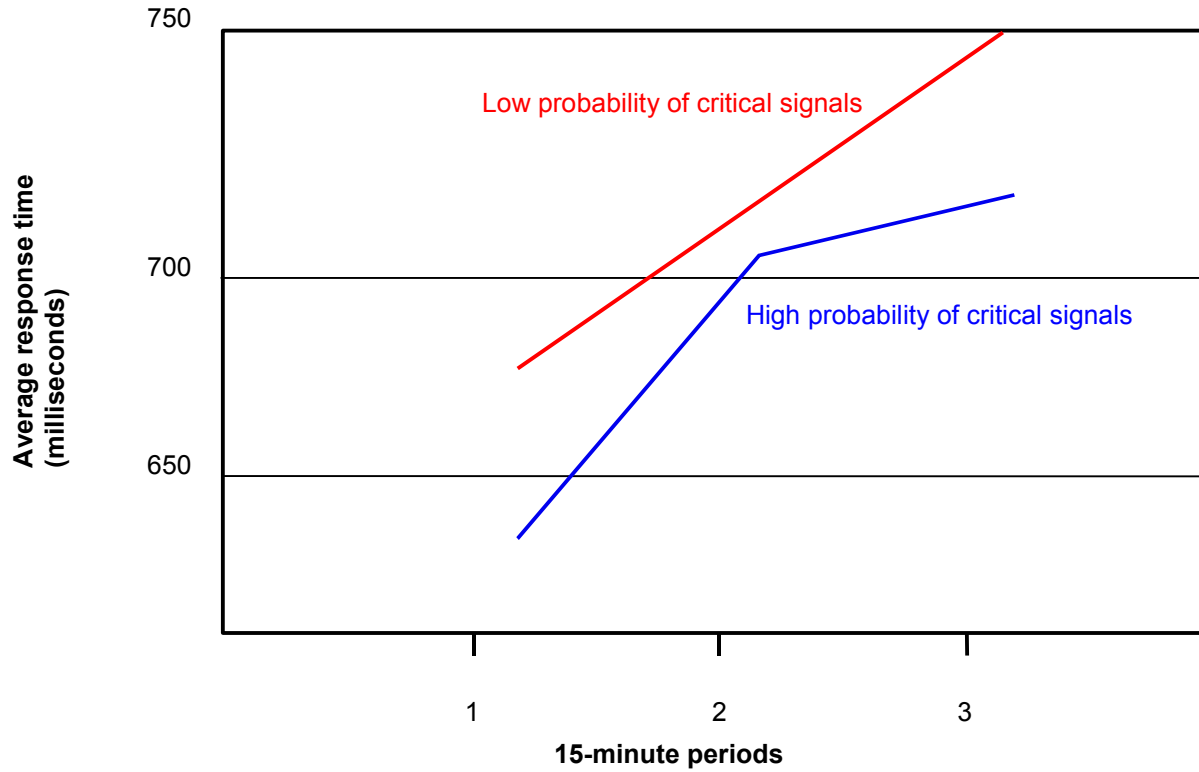
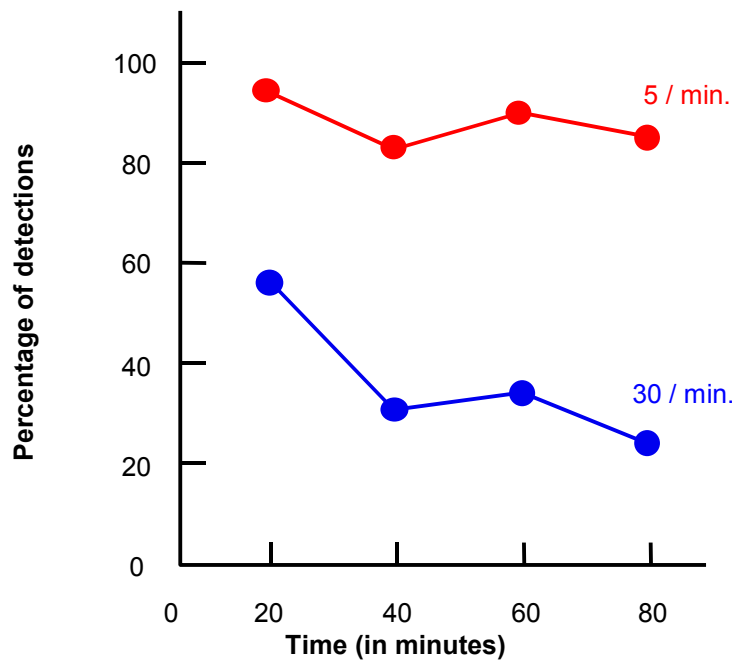


Figure #7

Effect of the Probability of Non-Critical Signals
(according to Jerison and Pickett, 1964)



Other more recent studies have sought to highlight the impact of attention type processes on the performance of a vigilance task. Let us recall that, according to the level of learning of the subject or the task's difficulty, two types of processes are used: controlled processes for tasks requiring great attention and automatic processes for tasks requiring little attention or for those for which intensive learning was obtained beforehand. The works of Fisk and Schneider (1981) showed that the use of controlled processes resulted in greater degradation of performances over time than was the case with the use of automatic processes.

Implications for Lifeguards: training, which contributes to "automating" the attention, can be a favorable element for maintaining the vigilance level of lifeguards.

Subsequent to these works, it was admitted that alternating both process types could help to maintain a subject's vigilance by having an effect on the situation's monopoly. Three conditions were compared (Cabon, 1992) in order to verify this hypothesis:

- a control situation wherein the task required only automatic processes,
- a daytime experimental condition wherein the subject had to alternate between automatic and controlled processes,
- a night-time experimental condition, identical with the daytime experimental condition, in order to verify the effect of alternating controlled and automatic processes when the operator is on a very low physiological activation level.

In this study, the vigilance task requiring only automatic processes was to monitor the movement of a cursor within a rectangular area and to press a button when the cursor moved into areas located to the left or right of this rectangle (Figure #8). A few seconds before the cursor's move, the subject was forewarned of the occurrence of this event by the presence of a warning signal (square). This indicated the zone in which the cursor would enter. This situation required very little attention, since the subject was always warned of which side to watch. The situation requiring the use of controlled processes only differed from the preceding task by the fact that the cursor could unpredictably enter the zone opposite the one where the square was located. In this case, the subject had to do nothing. This situation required more attention since the subject must memorize the square's position, compare it with the zone entered by the cursor, and then decide whether or not to answer.

The results (Figure #9) indicate that the performances remained at a stable level during the daytime experimental condition, unlike in the control condition where the omissions increased between the beginning and end of the task. This indicates that alternating processes is efficient in order to maintain vigilance. Nevertheless, this method only seems to work with a satisfactory physiological activation level, i.e. when the task is carried out during the daytime.

In the night-time condition, with an excessively low alertness level, the performance degraded despite the alternating automatic and controlled processes. The results of the studies served as the bases for recommendations in the area of radar surveillance and for maintaining the vigilance level of long-haul aircraft pilots (Cabon, 1992). These and other recommendations on vigilance maintenance were gathered into a guide and distributed to all pilots of French companies (Mollard and coll., 1995) and of foreign corporate clients of Airbus Industrie (Cabon and coll., 1995).

These activity alterations were also observed amongst nuclear station control room operators (Coblentz and coll., 1992): the operators, working in teams of two, spontaneously adopt periods of active and passive vigil in order to optimize the vigilance level.

Implications for Lifeguards: frequent changes in activities could help to maintain the vigilance level of lifeguards during the vigilance phases.

Figure #8

Description of the Vigilance Task

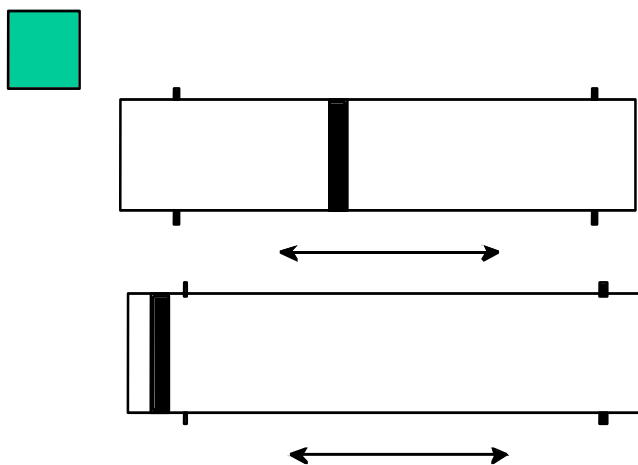
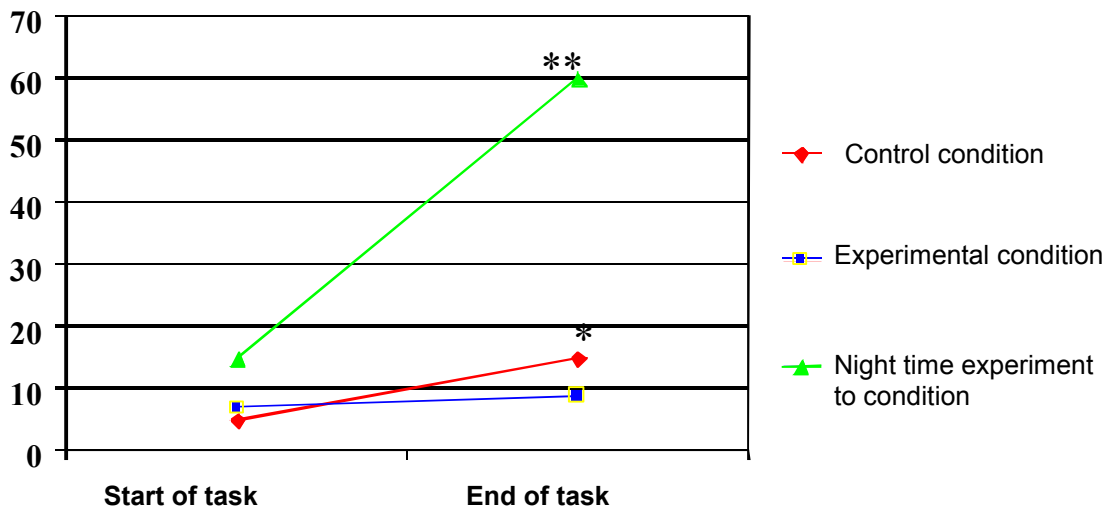


Figure #9

Number of Omissions at the Start and End of the Task for the Three Conditions
(according to Cabon, 1992)



* $p < 0,05$

** $p < 0,001$

4.2 - The Physical Surroundings

4.2.1 - Noise

Among the physical surroundings, noise has most often been studied since it has complex effects on vigilance. Indeed, the number of studies carried out has resulted in contradictory results, with certain studies showing that noise has a positive impact on performance, while others bring to

light a negative impact. The main explanation for these contradictory results can be found in the fact that noise's impact depends greatly on the subject's state when he/she is exposed to the noise. Wilkinson (1963) compared the performance of subjects during a vigilance test with four conditions combining a noise factor and a sleep deprivation factor in the days leading up to the test:

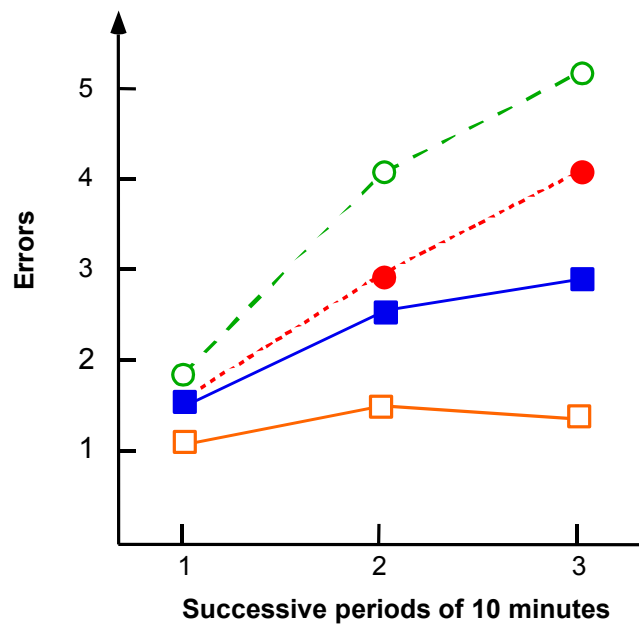
- sleep deprivation for 32 hours - task carried out in silence,
- sleep deprivation for 32 hours - task carried out with noise (100 dB),
- normal sleep - task carried out in silence,
- normal sleep - task carried out with noise (100 dB).

The results (Figure #10) indicate optimum performance in the condition combining normal sleep and silence. Noise produces a positive effect when the subjects have been deprived of sleep, and a negative effect when they have slept normally. The previously described inverted U law can be used to explain these apparently contradictory results. When the subjects have not been deprived of sleep, noise degrades their performance since their activation levels exceed the optimum level. Inversely, when deprived of sleep, noise improves the performance since it increases the alertness level above the optimum activation threshold. These results indicate that an external agent such as noise **does not produce the same effects on the basis of the operator's state.**

Other studies have shown that noise degrades an operator's ability to share his/her attention between several sources of stimulus. Hockey (1978) observes that the detection performance in the clock test is degraded under the effect of noise, but only when the subject must simultaneously monitor three clocks (Figure #11).

Figure #10

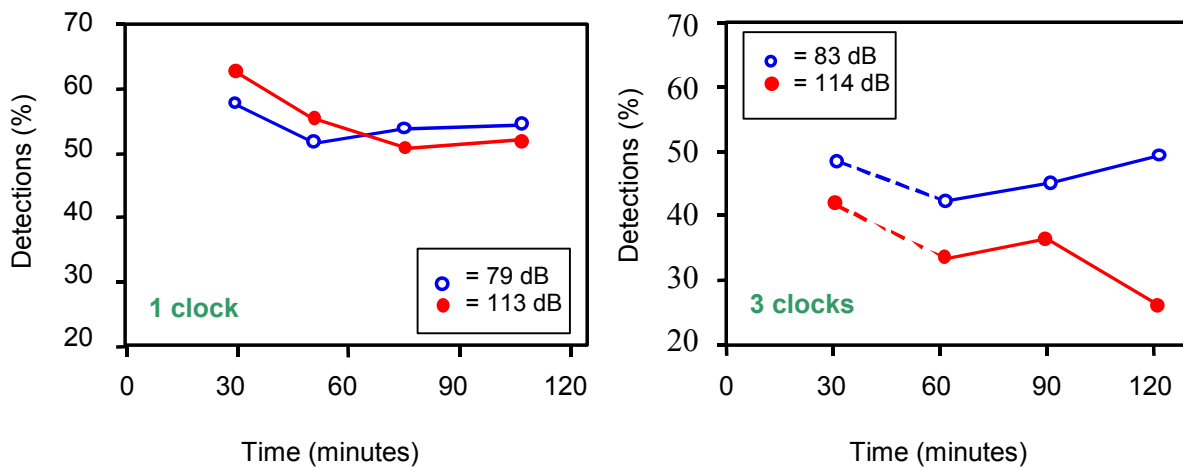
Effect of Noise and Sleep Deprivation
(according to Wilkinson, 1963)



○ - - - ○ Sleep deprivation (32 hours) - silence ■ - - - ■ Normal sleep - noise (100 dB)
○ - ○ Sleep deprivation (32 hours) - noise □ - - - □ Normal sleep - silence

Figure #11

Effect of Noise on Attention Sharing
(according to Hockey, 1978)



In the same study (Figure #12), the author studies the effect of noise in a double task situation wherein the subject must simultaneously carry out an unstable pursuit rotor test and a visual signal detection test. In the pursuit rotor test, the subjects must keep a cross within a randomly moving square. The detection test involved pressing a button upon the appearance of signals either in the central vision or within the peripheral vision. The subjects must carry out this double task with a sound intensity of 70 dB or 100 dB. In the pursuit test, noise primarily affected the performances over time. Within the first 10 minutes, the performances was higher in the 70 dB condition. Over time, the performance degraded at 70 dB whereas it remained constant in the 100 dB condition. In this study, the noise at the tested sound intensities therefore had a **positive impact on maintaining the psychometric performances over time**. For the detection test, the results indicate that noise's effect depend on the location of the signals: it improves the performance for signals present in the central vision, but degrades it with signals present in the peripheral vision. Based on these results, the author concludes that noise tends to **increase the focus of attention on the most dominant signals of any given situation**.

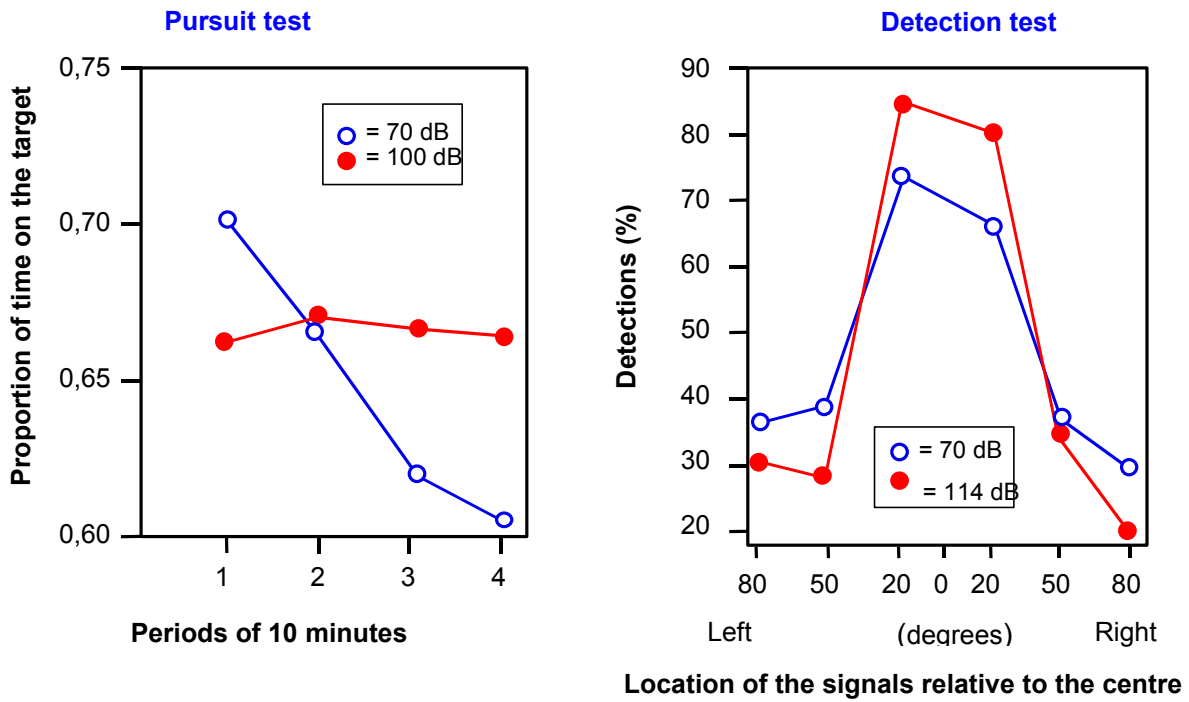
Implications for Lifeguards: noise, which is an essential environmental factor around a swimming pool, can contribute to reducing the possibilities for sharing one's attention and can increase the focusing of the lifeguards' attention, leading them to neglect elements located in their peripheral vision field.

4.2.2 - The Temperature

The effects of heat on the performance of a vigilance task were shown as far back as the works by Mackworth (1950) and those of Pepler (1953). The studies indicate that performance degrades significantly as of 30°C / 86°F (approx. 45% vs. optimal performance). Performance is affected much less at a temperature of 26°C / 79°F (approx. 30% vs. optimal performance). In addition to degrading performances, higher temperatures also result in significant physiological changes (thermoregulation), characterized by a shift of the blood volume to the periphery. These transformations result in an increase in the heart rate and blood pressure, which are likely to entail an important physiological impact on the subject.

Figure #12

Effect of Noise on the Performances During a Double Task Test
(according to Hockey, 1978)



The noise **increases** the act of focusing one's attention on a situation's most dominant signals

Implications for Lifeguards: heat is one of the factors which have a major effect on vigilance. Given the seasonal aspect of lifeguarding activities, lifeguards are often exposed to heat and to conditions which are not conducive to their performance.

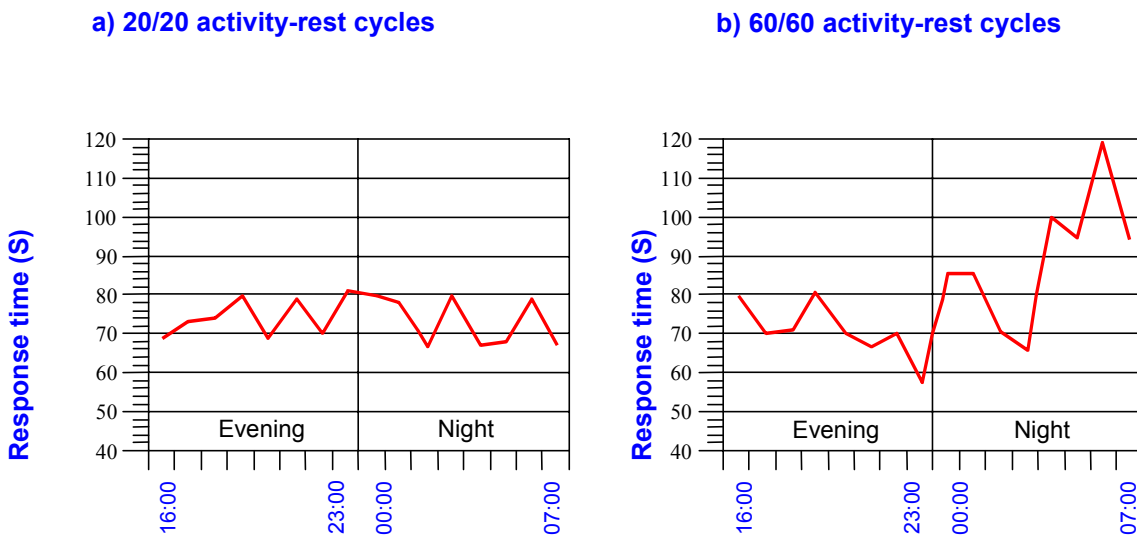
4.3 - The Temporal Progress of the Activity

Since the first studies on vigilance, several authors put forward the hypothesis that the duration of the task has an impact on the performance. Mackworth (1970) shows that the introduction of short breaks, even lasting only five to 10 minutes, was sufficient to return to the same performance level as at the beginning of the task. These breaks have a positive effect, whether the break is devoted to rest or to another activity. The essential factor of these breaks is therefore the **change of activities**. A more recent study (Pigeau, 1995) on air traffic control nevertheless shows that the duration of the break interacts with the time of day. The author compares two conditions for the duration of the activity-rest cycle: i.e. 20 minutes of work and 20 minutes of rest, or 60 minutes of work and 60 minutes of rest. These two conditions are studied during an evening shift and a night shift. The results (Figure #13) shows that the 20/20 cycle produces no difference between the performance on the evening shift and the night shift. However, with the 60/60 cycle, there is a degradation in performance only during the night shift. These results suggest that a long cycle is efficient for maintaining vigilance only when the alertness level is optimum (evening shift). However, when the activation level decreases (night shift), a long cycle damages the performance whereas the short cycle maintains it at the same level as during the evening shift. In other words, the **length of a break has a different impact according to the time of day and the subject's state of alertness**.

Implications for Lifeguards: it is better to adopt short activity-rest cycles, particularly at times associated with a low alertness level (early morning, beginning of the afternoon).

Figure #13

**Average Response Times Per Hour According to the Duration
of the Activity-Rest Cycle**
(according to Pigeau and coll., 1995)



5 - VIGILANCE AND THE PERFORMANCE OF LIFEGUARDS

It is extremely rare to find studies on the performance of lifeguards and on the factors affecting this performance. These studies, originating mostly in the United States and Australia, deal primarily with lifeguards at sea, given the much higher frequency of drownings in the sea than in pools. These works deal with two aspects: the description of drownings situations and the factors affecting the performance of lifeguards.

5.1 - The Drowning Situations

The works of Pia (1974) in the United States provide a description of the various drownings situations. These works brought to light two types of situations: distress situations and drowning situations. In distress situations, the swimmer is conscious but unable to return to safety without assistance. The swimmer maintains voluntary control of his/her actions, and calls for help with gestures or orally. For lifeguards, these situations are the easiest to detect.

Drowning situations can be classified into two types:

- **Passive Drownings:** the victims quickly slip below the surface, without prior calls for help or gestures. These drownings are generally linked to a sudden loss of consciousness (e.g.: heart attack). These situations are the most difficult to detect, as the victim is below the water's surface and gives no external sign of distress. The lifeguards must be able to identify a potential risk involving the various swimmers, and always be able to locate them.
- **Active Drownings:** the victim is conscious and can be detected by a trained and attentive lifeguard. The victim's behavior is very characteristic: the head is tilted back and the arms are flailing above the surface. Nevertheless, the victim does not call for help since the initial reflex is to breathe, which prevents the victim from calling out. The swimmer behaves in this manner for 20 to 60 seconds before slowly slipping below the surface. A lifeguard with only average training may confuse this situation with playing.

These works suggest that the various drowning situations likely to occur require that the lifeguards have good familiarity with the circumstances and with the main indicators to which they must pay attention.

5.2 - The Activity and Performance of the Lifeguard

In addition to giving swimming lessons and to pool maintenance operations, the lifeguard's main activity during the vigilance phases consists of a visual scanning of the areas where the swimmers are located. The main point in the detection performance is the quality of this visual scanning activity. This activity is generally not entirely haphazard, but is in fact directed by the lifeguard's attention on the basis of his/her familiarity with the premises and the movements of swimmers. This scanning must allow a quick movement from one zone to another, as a drowning

can occur in between 20 and 60 seconds. The lifeguard's attention must also be able to detect a critical signal (start of a drowning) from amongst a series of non-critical signals (swimmers on or below the water's surface).

The optimum detection performance is located in the central vision. In this area, the swimmer's face will be seen in the greatest detail. In the peripheral vision, the visual performance remains weak for static objects and increases for moving objects. This difference between central vision and peripheral vision implies that the lifeguard must rotate his/her head in order to visually scan all of the areas of the pool using the central vision.

A few studies have identified the main factors which affect the quality of the visual scan carried out by lifeguards. Harell (1999) demonstrated that the number of children in the pool reduced the number of visual scans of the pool due to the higher number of incidents and of rule breaking identified around the pool. The study also shows that the visual scan is of a better quality when the lifeguard is located above the level of the pool. Finally, the author indicates that the visual scans decrease in number throughout the day, probably due to fatigue.

Another factor likely to significantly affect the visual performance of lifeguards is the monotony of the situation. This monotony, related to the lifeguard's activity, can result in a high frustration level (Perkins and Hill, 1985). When combined with the need to remain vigilant, this monotony results in a high stress level, which has a negative impact on performance. This decreased performance results primarily in an increase in the response time within the central vision (Williams and Andersen, 1997). One of the possibilities for overcoming this monotony is to alter the tasks requiring different attention processes (Capon, 1992).

Lifeguards can also suffer stress as a result of rescue operations. Hansucker and Jen-Gwo Chen (1994) recorded lifeguards' heart rates, an indicator of stress, as well as the critical merger frequency, an indicator of visual fatigue. These recordings were made before and after simulated rescue operations in pools. After the rescue operations, an increase in both parameters was noted, an increase which is much greater when the situation is stressful than when it merely requires a physical effort. This indicates that the performance of lifeguards decreases after a rescue operation. One of the recommendations of the study was that lifeguards should be given some time to rest after operations of this type.

The temporal variations in lifeguard performance must also be taken into account. These variations are related to the biological clock which regulates all of the physiological and psychological functions. This notably results in a strong decrease in performance in the early afternoon, commonly known as the "post-prandial slump". And yet, this lower performance is not related to consuming food or digestion, but rather to a natural slowdown related to the biological rhythm. This decreased performance is increased by several factors, including inadequate sleep during the preceding nights, heat and a low motivation level. Moreover, there are significant individual differences in the scope and phase of these biological rhythms. Such data must be considered when planning lifeguard rotations. Fenner and coll. (1999) suggest that the lifeguards should play an active role in designing the rotations in order for the schedules to take into account the individual rhythms of each lifeguard.

Another particular aspect of the lifeguard's activity relates to the lifeguard's attention being distracted by the pool environment, notably by children running along the sides, questions asked by clients, etc. These elements can distract the lifeguard's attention, while a drowning can take place in 20 seconds.

6 - CONCLUSIONS - PROSPECTS

Despite the lifeguards' important role in the safety of users of public swimming pools, there have been very few works on the topic of vigilance and performance in this domain. This document therefore presents a summary of the data in the literature as obtained in laboratories and in other professional domains (automobile driving, airline pilots, industrial operators). Indeed, though transposing the results from one professional environment to another has limits, much can still be learned from these other domains, as certain aspects of the lifeguards' activities have similarities to other activities. This work serves to identify the main factors which can modify the vigilance state of lifeguards, as well as some initial recommendations.

- Laboratory studies show that the vigilance level will be higher as the number of relevant signals increases and the amount of non-relevant information decreases. However, the surveillance provided by lifeguards is characterized by many non-critical signals and very rare critical signals, which is unfavorable to maintaining the state of vigilance.
- Performance can be maintained by alternating between automatic and controlled attention processes. These results promote alternating activities (for example: vigilance, lessons, maintenance operations) rather than a continuous pool vigilance activity.
- Breaks have a very positive effect on the vigilance level, whatever their content. The improved performance is thus primarily attributable to a change in activities. Nevertheless, for optimum benefit, the frequency and duration of breaks must take into account the time of day: they must be more frequent and shorter when the alertness level is low, for example in the early afternoon.
- Among the ambient factors, noise has a complex effect on vigilance. It improves the performance when the alertness level is low, but degrades it when the alertness level is high. These results agree with the activation law which indicates that optimum performance can be attained with an optimum alertness level. Moreover, noise hinders the ability to share one's attention and tends to focus one's attention on the signals present in the central vision, to the detriment of those signals present in the peripheral vision. The heat, when over 30°C / 86°F, significantly reduces the vigilance.
- The performance of lifeguards can be affected by monotony, stress and fatigue. These aspects should therefore be taken into account when planning the working schedules of lifeguards.

The results of the works quoted in this document can, to a large degree, be applied to the tasks of a lifeguard, as these can be likened to a vigilance task. The particular environment of this job heightens the fragile nature of the performance: low number of critical signals and high number of non-critical signals, unfavorable physical surroundings (noise, temperature).

In this context, automatic drowning detection systems, such as the one developed by Poseidon Technologies, provide an invaluable assistance. However, no system can replace the human capacities in terms of detection and intervention. It is therefore essential to consider the operation of the man-system team and to study the possibilities for optimising its efficiency, including a reflection on the lifeguards' activities, education and training.

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