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RESEARCH

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Do Lifeguards Monitor the Events They Should?

Lyndsey K. Lanagan-Leitzel and Cathleen M. Moore

Lifeguard training texts suggest that a lifeguard should continually scan their zone of coverage, carefully examining patrons whose behavior is consistent with drowning or distress. The current study examined whether lifeguard performance is consistent with these specifications and whether these behaviors have enough visual interest to attract the gaze of non-lifeguards looking for drowning behaviors ("trained") or those who were given no specified target ("naïve"). Participants viewed video clips of natural swimming taken from three aquatic locations while an eye-tracker recorded their eye position. Lifeguard performance was to some extent consistent with the specifications above, although on many measures it was not statistically better than briefly-trained participants. Implications for future research and training are considered.

Swimming is a popular sport, enjoyed for leisure and for exercise. Beach and pool attendance has been climbing steadily since the beginning of the 20th century (see Branche & Stewart, 2001, for a review). During 2007, the United States Lifesaving Association (2009) reported that over 281 million swimmers attended their affiliated beaches. Swimming, however, can pose a risk: the World Health Organization (2003) reported that over 400,000 people died from accidental drowning in 2000. It is thought that having trained and certified lifeguards monitor swimming areas can reduce the incidence of drowning. Although detailed records are not kept for every swimming establishment, the United States Lifesaving Association compiles records for their affiliated lifeguard-staffed beaches (estimated to be 95% of all lifeguarded beaches in the U.S.) and some lifeguarded pools (Branche & Stewart, 2001). They reported that during 2007, only 20 people died from drowning at these locations, while over 74,000 people were rescued (United States Lifesaving Association, 2009).

When swimming first became popular in the 1800s, there were many more instances of drowning than there are today (see Branche & Stewart, 2001, for a review). The early lifeguard was seen as a life*saver*—a person responsible for rescuing people who were drowning. More recently, the role of the lifeguard has changed to that seen today—a person responsible for keeping patrons safe by trying to prevent drowning, but being prepared to respond with a rescue should the threat of drowning occur (Branche & Stewart, 2001). Lifeguards thus engage in constant

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surveillance of their assigned zone in the water. Although an occasional rescue may be warranted, surveillance is still the primary component of their day-to-day work experience.

If surveillance is the primary component of the lifeguard's job, one would expect extensive coverage of proper surveillance methods in the lifeguard training manuals. The American Red Cross is a leader in lifeguard training and certification, training approximately 140,000 lifeguards each year (American Red Cross, 1995). In their most recent training manual (containing 11 chapters), only one is devoted to patron surveillance, while six are devoted to rescue technique and first aid (American Red Cross, 2007). Rescue technique and first aid also are a predominant factor in the certification process, while surveillance plays a less crucial role. It is possible that lifeguards lose sight of the importance of surveillance when the focus is so much upon the rescue and first aid techniques.

The degree of coverage dedicated to surveillance methods in other popular certification training texts is similar to the Red Cross. The training manual published by Ellis and Associates (2007) includes 14 chapters, with only one detailing drowning recognition. Both the United States Lifesaving Association (2003) manual (26 chapters) and the Starfish Aquatics Institute training manual (White, 2006; 15 chapters) are slightly better in that they each have one chapter focused on surveillance/scanning and one chapter focused on identifying a drowning. Reviewing each of these manuals reinforces the perception that the predominant focus of training is on rescue and first aid, not on surveillance.

The way that these training manuals examine surveillance is very similar, although there are a few notable differences among the approaches. The coverage of surveillance in each text focuses on two basic processes—how to scan the zone of coverage and how to identify a drowning when it occurs. Proper scanning ensures that each swimmer is monitored and no swimmer is ignored. Yet, even with proper scanning, lifeguards must also be able to identify a drowning when it occurs and identify precursors that allow them to take preventative action to ensure that a drowning does not occur.

Different manuals have different approaches to the task of scanning. The American Red Cross manual (American Red Cross, 2007) teaches its readers to "scan from point to point, rapidly watching all movements of the patrons in the area" (p. 31). Although readers are told to devote less of their attention to people who appear to be strong swimmers, they are told to continue to monitor them nonetheless. This approach may lead to a haphazard scanning process, where it may be difficult to keep track of which swimmers have been monitored. In the Starfish Aquatics Institute training manual (White, 2006), on the other hand, scanning is covered in two ways. First, the Starfish Aquatics Institute advocates a "3-D triage scanning," prioritizing those swimmers who are most in need of attention (i.e., those who are submerged and closest to the bottom of the pool). Second, the manual advocates the use of the "5-minute scanning strategy" developed by Griffiths (2000), which requires a sweeping scan along an individually-chosen geometrical pattern in five-minute increments. With each new five-minute segment, a new geometrical pattern and new body posture is chosen to allow the lifeguards to remain vigilant and combat boredom. The combination of these two strategies may promote frequent examinations of weaker swimmers and more coverage of the assigned zone.

Even when lifeguards appear to be monitoring their assigned zone, it is unclear if they will notice every drowning. Lifeguard surveillance was examined by Ellis and Associates (reported by Brener & Oostman, 2002) by placing a lifelike child-sized mannequin under the surface of the water in a particular lifeguard's zone of coverage. They then timed how long it took the lifeguard to notice the submerged mannequin and recorded the lifeguard's head movements to see if failure to notice the mannequin was due to faulty visual scanning. The trial was stopped when the lifeguard noticed the mannequin, or after three minutes. Studying 500 lifeguards at 90 different pools, the average amount of time it took the lifeguards to notice the mannequin was 1 minute and 14 seconds. Lifeguards in training are taught that brain damage is possible within five minutes of submersion (see American Red Cross, 1995; White, 2006), so an ideal response is to notice a drowning much faster than this to provide enough time for rescue and resuscitation procedures. This research led Ellis and Associates to recommend that a drowning be noticed within 10 seconds after it begins and a rescue initiated within the next 20 seconds, to minimize this health risk. Only 9% of the lifeguards in the study reported by Brener and Oostman (2002) noticed the mannequin within 10 seconds. Far more troubling, 14% of lifeguards did not notice the mannequin at all until it was raised out of the water after three minutes. Review of the videotape records indicated to these researchers that the lifeguards who failed to notice the mannequin were scanning as they were trained to do—they simply failed to notice the drowning. This study, despite being conducted by a training agency and not subject to peer review, nevertheless suggests that further study of lifeguard surveillance is necessary.

Lifeguards are taught a set of specific behaviors that are thought to indicate that a drowning is occurring or imminent (see American Red Cross, 1995, 2007; Ellis & Associates, 2007; United States Lifesaving Association, 2003; White, 2006). A swimmer who is in distress is one who is struggling to stay afloat and may be cognizant enough to be able to call out for help and grab onto lane dividers, the pool edge, or rescue equipment. If unaided, a distressed swimmer could begin to panic and demonstrate a set of behaviors known collectively as the *instinctive drowning response* (Pia, 1974). This set of behaviors includes sinking very low in the water and frequent submerging, coupled with frantic efforts to keep the mouth and nose above the surface of the water (through flailing arms and a head that is tilted back). At this stage, the drowning person is devoting full attention to staying above the surface of the water, so s/he may be unable to call out for help. This struggle only lasts as long as the patron's energy permits—a weak patron or a child may struggle for less than a minute before submerging. Once the patron slips underwater and can no longer breathe, critical body functions that require oxygen begin to shut down. The heart stops beating, preventing oxygen from reaching the brain. The longer a person is submerged without oxygen, the greater the risk of permanent brain damage, so lifeguards are taught the behaviors associated with each of these stages and are instructed to search for patrons exhibiting any of these behaviors.

Note that the behaviors associated with drowning and distress are presented as behaviors that must be acted on immediately (in the case of drowning) or behaviors that warrant frequent monitoring until the situation resolves (in the case of distress). Even though drowning and distress are not a common part of the lifeguard's day, the specific behaviors are. Because lifeguards are taught that these behaviors indicate a serious problem, lifeguards may choose to search for these behaviors and evaluate them when they occur.

It is unknown to what extent lifeguards rely on these specific behaviors to guide their search. In-depth study of lifeguard surveillance has only recently begun. Research by Harrell (1999, 2001; Harrell & Boisvert, 2003) suggests that lifeguards tend to increase their overall scanning, as assessed by overt head and eye movements, when the ratio of children to adults increases. Harrell suggests that lifeguards may view children as a risk group and increase their surveillance when they are present. Schwebel, Simpson, and Lindsay (2007) examined lifeguard surveillance and patron risk-taking behavior via poolside observation and concluded that lifeguards were often distracted (not looking at their assigned zone) and only warned patrons about dangerous behavior a fraction of the time it occurred. After a brief intervention program designed to call attention to their distraction and the real risk of drowning, Schwebel, Lindsay, and Simpson (2007) found that the lifeguards increased their scanning behavior and were less distracted. These studies examined general lifeguard surveillance (i.e., how often a noticeable movement of the head or eyes occurred) but not which patrons were actually monitored.

The current study examines the extent to which critical events—those identified by lifeguard experts as important to monitor—guide lifeguard and non-lifeguard surveillance. In practice, most of the critical events were identified as critical because the patron behavior was described by the lifeguard manuals as being a component of drowning or distress (e.g., splashing, submersion, weak or slow swimming stroke). It is important to note, however, that no actual drowning or distress events occurred in the video clips, but these behaviors in isolation are a frequent occurrence in a lifeguard's typical viewing experience.

The rescue rate at lifeguarded beaches and pools dramatically surpasses the drowning rate (United States Lifesaving Association, 2009), suggesting that lifeguards may be capable of noticing most instances of drowning. It is unknown, however, whether they search for the behaviors that they were taught or whether they develop other strategies independently to complete the task. Understanding what strategies lifeguards use could facilitate the development of more effective training materials.

A review of the lifeguard training manuals (American Red Cross, 1995, 2007; Ellis & Associates, 2007; United States Lifesaving Association, 2003; White, 2006) suggests that an effective lifeguard should do the following:

- Scan (keep the eyes moving) except when evaluating patron behavior.
- Examine patrons displaying behaviors that could indicate distress or drowning and frequently reexamine those patrons until the situation is resolved or a decision is made to rescue or assist.

In this study, we examined the extent to which lifeguard surveillance is consistent with these recommendations. Lifeguards were asked to monitor several short video clips of aquatic activity while their eye position was recorded. Of particular interest was the content of their eye fixations: specifically, whether fixated swimmers were identified as critical events or were demonstrating any of the prescribed behaviors. If lifeguards forget the behaviors or can't use their training effectively, then they may resort to letting their surveillance be driven by events in the scene, paying close attention to events that are unusual and salient. This would predict that the success of the lifeguard at locating drowning patrons would be no better than that of an untrained person watching the pool.

To assess the extent to which these critical events are visually salient and to what extent an untrained person can search for an entire set of behaviors, non-lifeguards were also asked to monitor the same video clips with either a specified target (looking for the set of behaviors described by the lifeguard training manuals—"trained" group) or no specified target (for whom surveillance was presumably driven entirely by visual salience and interest value—"naïve" group). If lifeguards fixated more of the critical events and prescribed behaviors than the naïve group, this indicates two things. First, it indicates that lifeguards are capable of searching for the set of behaviors they were taught, although it does not rule out the occasional use of salience in surveillance. Second, it indicates that at least some critical events are not salient (i.e., events missed by the naïve group but monitored by the lifeguards). If lifeguards outperform the trained group, this could indicate that the set of prescribed behaviors is difficult for a novice to simultaneously seek and process—with experience, lifeguards may develop strategies to assist them in this task.

Method

Participants

Thirty Penn State University students were paid to participate in this study. Ten were trained lifeguards (this *lifeguard* group contained one male and nine females, average age 21.4 years). All ten were or had been certified by the American Red Cross (eight were certified at the time of test) and were recruited through word-of-mouth, e-mail advertisements to lifeguards employed at the Penn State natatorium, and signs posted in the psychology department. These lifeguards differed in terms of work experience: eight only had experience with pools, while the other two had experience with both pools and lake/ocean environments. The ten lifeguards also differed in the number of years they had been working as a lifeguard: three had only been working for 1 year, four had been working 3-4 years, and the remaining three had been working for 6-7 years.

The remaining 20 participants (7 males, 13 females, average age 20.9 years) were not lifeguards and had never been trained as lifeguards. Ten of these 20 (the *trained* group) were given a brief training segment on the behaviors associated with drowning (see below). The remaining ten participants comprised the *naïve* group. All were recruited through word-of-mouth and posted advertisements in the psychology department. There were three additional participants run—one lifeguard and two non-lifeguards, all males with an average age of 20.0 years, but their fixation data were unusable due to frequent head movements.

Apparatus

Stimulus videos were presented on a color monitor controlled by a PC computer running Matlab software with the Psychophysics Toolbox libraries (Brainard, 1997; Pelli, 1997). Eye position was monitored during viewing of the videos by a video-based monocular eye-tracker (Arrington Research Labs) running Viewpoint software (Version PC60). Viewing distance was fixed at 32 cm, using an Arrington Quickclamp chin- and head-rest system.

Stimuli

The stimuli were 60 thirty-second video clips of aquatic scenes. These videos were recorded using a Sony HandyCam digital camcorder (model DCR-TRV280), and the videos were digitized to AVI files by the movie software WinDVD. Three aquatic scenes were recorded—an indoor lap pool and diving well used by adults, a Pennsylvania state park (a lake with children and teens), and an outdoor pool with some adults and many children. Each location was visited at least twice (the indoor pool was visited four times due to homogenous activity and few swimmers), and several different views of each location were recorded. In the set of 60 video clips, 20 were from the indoor pool (6 viewing the diving well, 7 viewing one half of the lap pool, and 7 viewing the other half of the lap pool), 20 were from the lake (10 viewing the swimming area from the side and 10 viewing the swimming area from across the lake with the beach in the background), and 20 were from the outdoor pool (10 viewing the pool from the side and 10 viewing the pool from the deep end). These views were chosen not to reflect an actual lifeguard's view but to ensure many swimmers in each video, providing the participant with many options for eye fixations. There were no instances of drowning at these locations during filming, but the prescribed behaviors discussed above (e.g., splashing, submersion, weak or slow swimming stroke) were prevalent.

Task

Lifeguards were instructed to monitor the videos as they would if they were on duty and responsible for every swimmer within the video frame. They were told that although they were watching videos (and therefore rescue wouldn't be possible), they should indicate any serious situations with their eye position. They were given no additional training or reminders of drowning behaviors or scanning procedures, because the goal of this study was to determine whether these trained lifeguards actually look for the behaviors and events they were trained to find.

Participants in the trained group were given a brief training segment on their target behaviors. The instructions, adapted from American Red Cross (1995), were the following:

> An unconscious victim is motionless, and may be either on the surface of the water or at the bottom. Many lifeguards report that unconscious victims on the bottom of a pool tend to look like a towel or smudge on the bottom instead of a person, because the water above distorts them.
>
> When the victim is conscious, their body is on the surface or just beneath the surface and is usually vertical or on an angle. Their head is usually tilted back so that they can gasp for air as their face bobs above the surface. They are also panicking, so their arms might flail wildly at the surface of the water, and their face might have a panicked expression. (pp. 56-59)

These participants were shown still images of these behaviors (from White, 2006, pp. 38 and 42) to reinforce the training, and were told to look for these behaviors (e.g., submersion, splashing, low profile in the water, splashing) in the video clips.

Participants in the naïve group were told to watch the videos and look at "whatever interested them." These participants were recruited only knowing that the study investigated visual attention, not that it was going to examine lifeguarding. The instructions were intentionally left vague in order to induce these participants to rely on stimulus salience or visual interest to drive eye movements. By examining which behaviors draw attention automatically, we can determine how much of the lifeguard's task requires effortful surveillance, as opposed to passive surveillance.

Procedure

After providing informed consent, each participant underwent a calibration routine to ensure the eye-tracker was properly recording eye position. Each participant was then given instructions depending on group (*lifeguard*, *trained*, or *naïve*; see above). Lifeguards completed a brief computerized survey about their certification and experience. Each participant then viewed the 60 video clips, presented in a randomized order. They were instructed not to move any part of their body other than their eyes during each clip, but they were allowed to rest and move between clips. To ensure that the eye-tracker was still correctly recording eye position, each clip began with a still frame image from the clip with the participant's eye position marked by a dot. Participants were instructed to examine two or three objects within the scene, verifying that the dot appeared on the same object they were watching. If the recorded fixation was correct, participants pressed the space bar to watch the full clip without the dot. If the recorded fixation was incorrect, participants were instructed to make tiny head movements to return their head to the position it had been in at calibration. When this process failed, the experiment was suspended and the eye-tracker was recalibrated. This only had to be done once for each of three participants. In between each video clip, the participant was given a self-paced break.

Analyses

The analyses examine eye fixations, determined from the (x,y) coordinate recorded by the Viewpoint software for each frame of each video for each participant. A fixation is defined here as the eye's position remaining within one degree of visual angle from the previous eye position for at least 10 successive video frames (approximately 0.3 sec). One degree of visual angle is equivalent to an area that is approximately 0.5 cm in diameter at a viewing distance of 32 cm. This criterion was selected because it was small enough to ensure separate fixations for surveillance of different patrons. The duration of 0.3 sec was chosen because research has demonstrated a neural signature of recognition that appears in approximately this amount of time (Johnson & Olshausen, 2003). Matlab with the Psychophysics Toolbox libraries (Brainard, 1997; Pelli, 1997) was used to identify and classify fixations.

The analyses were driven by the qualities of an effective lifeguard reviewed above. Recall that an effective lifeguard should

- Scan (keep the eyes moving) except when evaluating patron behavior.
- Examine patrons displaying indicators of distress or drowning and frequently re-examine those patrons until the situation is resolved or a decision is made to rescue or assist.

To assess the degree to which lifeguard and non-lifeguard surveillance is consistent with these goals, three separate analyses were done.

The first analysis examined the frequency and duration of fixations as an index of scanning. Greater scanning would be demonstrated with fewer fixations that are shorter in duration. Lifeguards, because they are taught that they should continually scan their zone, should have fewer fixations and shorter fixations than non-lifeguards.

The second analysis examined monitoring of critical events. A critical event was defined as any event that a lifeguard should monitor carefully during the surveillance process. To determine which events in the videos were critical, two lifeguard training and research personnel[1] were enlisted to jointly view the videos and point out any events that lifeguards should frequently monitor, and explain why the event was critical. These critical events included behaviors such as splashing, submersion, jumping, or diving. Some critical events were characterized as indicators of swimmer weakness or lack of skill, such as swimming slowly and hanging onto a pool edge. Lifeguards should monitor more of these critical events than non-lifeguards. Also, because the trained group received a brief training on several of the behaviors demonstrated in the critical events, they should monitor more of these critical events than the naïve group.

To assess to what extent surveillance is driven by knowledge of the behaviors prescribed above, a third analysis examined every fixation within a subset of 12 video clips (4 from each location). The clips were chosen to provide a range of activity level and number of critical events. The different aquatic environments had a different prevalence of critical events, so the selection was based on these relative frequencies. The four clips from each aquatic location represented a maximum number of critical events for that location, a minimum number of critical events for that location, and two clips with a median number of critical events for that location.

Every fixation by each participant in each of these clips was examined. These fixations were classified generally into four categories (*off-camera*, *off-water*, *on-water/off-swimmer*, and *on-swimmer*). Fixations on swimmers were further classified into seven categories determined by the predominant behavior being demonstrated by the swimmer – *bobbing or low profile, splashing, submersion* (prescribed drowning indicators), *slow swimming, using a flotation device or hanging onto pool edges* (indicative of fatigue or lack of skill), *weird behavior*, or *other.* "Weird" behaviors were visually distinctive and/or unexpected events. This category included behaviors such as a patron swimming laps in a diving well with synchronized swimmers and a boy suddenly standing up and skipping a stone across the surface of the lake. This third analysis allowed for an examination of the extent to which lifeguards and non-lifeguards periodically re-fixate critical events and whether swimmers demonstrating any of the drowning or distress behaviors are fixated more frequently than those who are not.

Results

Fixation Frequency and Duration

For each of the 60 clips, the number of fixations by each participant was counted and their durations were averaged. Because the individual clips were not important to the current analysis, participant monitoring was collapsed across this variable, yielding two variables of interest—the average number of fixations per clip and the average length of each fixation. The overall effect of group on the number of fixations per clip was significant: $F(2, 27) = 4.808$, $p = 0.016$. Lifeguards had more fixations than naïve participants, 31.32 versus 26.64 fixations, $t(18) = 2.538$, $p = 0.021$, but lifeguards did not differ from trained participants, 31.32 versus 29.80 fixations, $t(18) = 1.789$, *ns*. Trained participants did not differ from naïve participants: 29.80 versus 26.64 fixations, $t(18) = 1.828$, *ns*. The overall effect of group on the average length of fixations was not significant: $F(2, 27) = 1.305$, *ns*. All of these effects are represented in Table 1.

Critical Event Monitoring

Across the 60 video clips there were 150 critical events. Seven of these video clips (all from the indoor pool) had no critical events. Consistent with expectations, there was a significant relationship between participant group and the percentage of

Table 1 Summary of Analyses Conducted

Group	Lifeguard[a]	Trained[b]	Naive[c]
Full Dataset			
Average number of fixations (per video clip)	31.32	29.80	26.64*
Average fixation length (seconds)	0.69	0.74	1.05
Average percentage of critical events monitored	54.0	49.2	41.4*
Clip Subset			
Average number of actual fixations (per clip)	25.00	23.55	19.45*
Average number of critical events monitored (out of 29)	20.9	20.2*	16.4*
Average number of fixations on critical events	74.7	82.8*	51. 4*
Percent of fixations off-camera	1.54	2.17	1.40
Percent of fixations off-water	10.65	13.02*	19.49*
Percent of fixations on-water but off-swimmer	15.28	19.23*	10.87*
Percent of fixations on bobbing/low profile	4.87	5.24	4.68
Percent of fixations on splashing	8.94	8.94	8.23
Percent of fixations on submersion	4.87	7.08	4.82
Percent of fixations on fatigued/slow swimmers	4.61	3.40	4.23
Percent of fixations on swimmers clinging to flotation devices, lane dividers, or pool edge	5.54	7.40	8.64
Percent of fixations on weird behavior	7.92	8.33*	11.11*
Percent of fixations on other behavior	61.58	58.77	57.45

[a]Significance values refer to difference between Lifeguard and Trained groups (none).

[b]Significance values refer to difference between Trained and Naïve groups.

[c]Significance values refer to difference between Lifeguard and Naïve groups.

*$p < .05$

critical events fixated, $F(2, 27) = 4.724$, $p = 0.017$; see Figure 1. Lifeguards monitored a greater proportion of critical events than naïve participants, 54.0% versus 41.4%, $t(18) = 2.823$, p = 0.011, but the difference between lifeguards and trained participants was not statistically significant, 54.0% versus 49.2%, $t(18) = 1.419$, *ns*. The difference between trained participants and naïve participants was also not statistically significant, 49.2% versus 41.4%, $t(18) = 1.744$, *ns*. Naïve participants ranged from observing 18.67% to 53.33% critical events, while trained participants ranged from 38.67% to 59.33%, and lifeguard participants ranged from 42.67% to 66.67%. Note that the data from the naïve participants is most intriguing – they were not given any instruction about what behaviors are critical to monitor, so it is surprising how many of the critical events they monitored without training. The wide variability across members within groups indicates why some of the differences were not statistically significant at $\alpha < .05$.

Monitoring for Distress/Drowning Across 12 Video Clips

The first analysis conducted examined the number of actual fixations. The number of fixations in the analysis above is a reflection of the computer process used to determine fixations. Recall that a fixation was defined as at least 10 frames where the eye does not move more than one degree of visual angle from one frame to the next. Objects in the videos sometimes subtended more than one degree of visual angle or were moving at a sufficient rate of speed to surpass this distance, so a participant who was monitoring an object may have moved his or her eyes more than one degree of visual angle while monitoring the same object. In the *fixation*

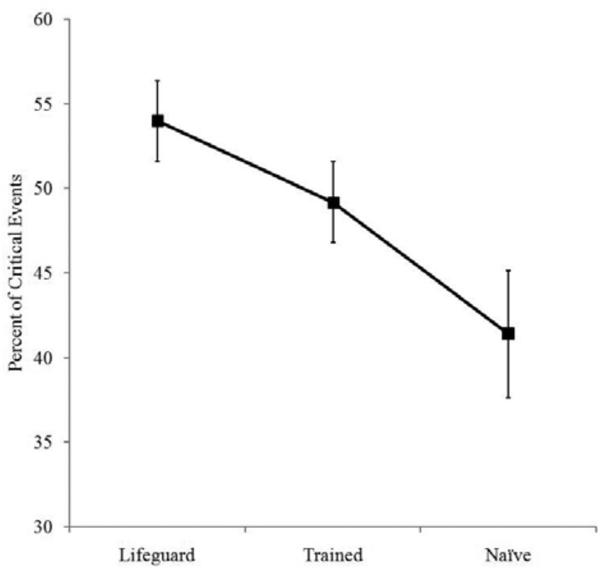

Figure 1 — Relationship between participant group and the percentage of critical events fixated.

frequency and duration analysis above, this may have been classified as two or more fixations in a row. Similarly, because the eye moves during a blink, blinking in the middle of a long fixation would have produced two different fixations. For these 12 clips, these multiple, successive fixations on the same object (with fewer than 10 frames or 0.3 second elapsing between them) were combined into one. Lifeguards still had the most fixations overall (an average of 25.0 per clip), followed by the trained participants (23.6), and the naïve participants (19.5). The overall effect of group on fixations was significant, $F(2, 27) = 5.389$, $p = 0.011$. The difference between the lifeguards and the naïve participants was significant, $t(11.148) = 2.735$, $p = 0.019$, Levine corrected, although the difference between the lifeguards and the trained participants did not reach significance, $t(18) = 1.497$, *ns*, and the difference between the trained participants and the naïve participants was also not significant, $t(18) = 2.008$, *ns*. These "combined" fixations are the basis for all further analyses reported here.

To assess whether lifeguards continue to monitor ongoing critical events to ensure they are resolved, the total number of fixations on critical events was assessed, in addition to the number of critical events fixated. Across the 12 clips, there were 29 critical events. All of these events were monitored by at least one participant, although one event was missed by all naïve participants, and only monitored by one trained participant and three lifeguards. This event involved a patron's head barely visible behind the front edge of the pool. The lifeguard experts identified this event and stated that because the patron's body was mostly obscured by the edge of the pool and was bobbing, s/he could have been experiencing distress and the lifeguard would be unaware of it. In an actual pool setting, the lifeguard should shift to a new position to allow the patron's behavior to be monitored, but that was not possible in these videos.

Three analyses were conducted to examine monitoring of critical events—the number of critical events monitored (out of 29), the total number of fixations on those critical events, and the number of video frames during which the participant was fixating a critical event. The effect of participant group on number of critical events monitored was significant, $F(2, 27) = 5.158$, $p = 0.013$, as was the effect on the total number of fixations on critical events, $F(2, 27) = 8.400$, $p = 0.001$, but the effect of participant group on the total amount of time spent fixating critical events was not significant, $F(2, 27) = 0.656$, *ns*.

The significant effects of participant group on the number of critical events monitored and the total number of fixations on critical events were examined further. The naïve participants monitored fewer critical events than trained participants, 16.4 versus 20.2 events, $t(18) = 2.442$, $p = 0.025$, and had fewer critical event fixations overall, 51.4 versus 82.8 fixations, $t(18) = 3.461$, $p = 0.003$. Lifeguards did not differ from trained participants on either measure, 20.9 versus 20.2 events fixated, $t(18) = 0.474$, *ns* and 74.7 versus 82.8 fixations, $t(18) = 0.985$, *ns*. Lifeguards differed from naïve participants on both the number of critical events fixated, 20.9 versus 16.4, $t(18) = 3.024$, $p = 0.007$, and the number of fixations on those events, 74.7 versus 51.4, $t(18) = 3.691$, $p = 0.002$. This suggests that the trained participants' behavior toward those events that were "critical" (according to the two lifeguard training and research personnel consulted) was very similar to that of the lifeguards, despite the trained participants only having had a brief training segment on the behaviors associated with drowning.

Focusing upon the initial fixation classification as *off-camera*, *off-water*, *on-water/off-swimmer*, and *on-swimmer*, there was no effect of participant group on percentage of fixations off-camera, $F(2, 27) = 0.469$, *ns*; see Figure 2. There were significant effects of participant group on both the percentage of fixations off-water, $F(2, 27) = 10.320$, $p < 0.001$, and the percentage of fixations on-water/off-swimmer, $F(2, 27) = 7.946$, $p = 0.002$. Lifeguards and trained participants did not differ in percent of fixations off-water (10.7% versus 13.0%, $t(18) = 1.270$, *ns*). Lifeguards did have significantly fewer fixations off-water than naïve participants, $t(18) = 4.079$, $p = 0.001$. Trained participants had fewer fixations off-water than naïve participants (13.0% versus 19.5%; $t(18) = 3.229$, $p = 0.005$). Trained participants had the most fixations that were on-water/off-swimmer (19.2%) compared to naïve participants (10.9%), a difference that was statistically significant, $t(18) = 3.456$, $p = 0.003$, but they were not significantly different than lifeguards (15.3%, $t(12.449) = 1.855$, *ns*). The difference between the lifeguards and the naïve participants was statistically significant, $t(18) = 2.625$, $p = 0.017$.

Each of the seven categories of swimmer behavior was subjected to a similar ANOVA. One category (weird behavior) reached significance, $F(2, 27) = 5.111$, $p = 0.013$; lifeguards had fewer fixations on weird behaviors than trained participants, although this difference was not statistically significant (7.9% versus 8.3% per clip; $t(18) = 0.413$, *ns*), and trained participants had fewer fixations on weird behaviors than naïve participants, 8.3% versus 11.1% per clip; $t(18) = 2.346$, $p = 0.031$. The difference between the lifeguards and the trained participants was also statistically significant, $t(15.694) = 2.947$, $p = 0.010$, Levine corrected.

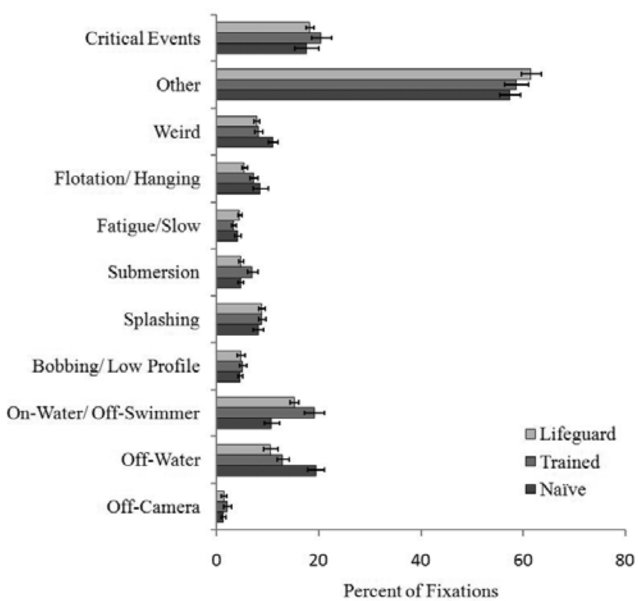

Figure 2 — Effect of participant group on percentage of fixations off-camera.

The category of submersion only approached significance, $F(2, 27) = 3.178$, $p = 0.058$, and given its association with drowning, this relationship was investigated further although no pairwise significant differences were likely. The differences among trained participants on submerged swimmers (7.1%) were not significant when compared to either naïve participants, 4.8%; $t(18) = 1.945$, *ns*, or lifeguards, 4.9%; $t(18) = 1.939$, *ns*. The difference between naïve participants and lifeguards also was not significant, $t(18) = 0.065$, *ns*. It appears as if all participants monitored the drowning behavior *submersion* and may have relied heavily upon that behavior to guide their search. In these clips, submersion events tended to be rather dramatic—running jumps, dives, and bobbing—that resulted in an extended period of time underwater.

Discussion

Lifeguards are taught a specific set of behaviors that are supposed to indicate drowning and may be critical to monitor, yet the largest focus of the training and certification process tends to be on rescue techniques and first aid. Because of this, it is possible that lifeguards may forget the visual scanning behaviors they were taught. Although lifeguards are largely successful (rescuing thousands of people every year), it is unclear whether they are actually searching for a combination of these behaviors as they were taught or whether they have developed alternate strategies independently.

In this study, we examined whether lifeguards search for the behaviors they were taught in training and to what extent these behaviors may be salient enough for non-lifeguards to notice. The results show that lifeguards do search for the behaviors that they were taught to look for, at least some of the time, and some of the critical events that are important for a lifeguard to monitor can be salient enough for even a non-lifeguard to notice. Interestingly, non-lifeguards also monitored the critical events, and many behaviors were not monitored any more often by lifeguards than by non-lifeguards. A review of the lifeguard training manuals (American Red Cross, 1995, 2007; Ellis & Associates, 2007; United States Lifesaving Association, 2003; White, 2006) suggested that an effective lifeguard should keep his/her eyes moving and examine (and periodically re-examine) patrons exhibiting behaviors that may indicate they are in danger. Participant group did affect the number of fixations, but there were no statistically significant differences between lifeguards and trained participants, or between trained participants and naïve participants. The large variability within groups as well as the small statistical power due to a small sample size could explain why many of the comparisons failed to reach significance (at $\alpha < 0.05$) Finally, although lifeguards monitored a greater proportion of critical events than trained and naïve participants, this difference was not statistically significant.

To examine whether critical events were re-fixated, and to what extent gaze was driven by the specific behaviors prescribed by lifeguard training organizations, a subset of the data was analyzed in more detail. This analysis showed that there were no large differences between lifeguards and non-lifeguards in monitoring behaviors consistent with drowning or distress. This suggests either that the behavior present in the video was salient enough to attract the attention of the non-lifeguards or that the lifeguards had modified their search strategy away from searching for specific behaviors they were taught in training.

The analyses conducted in this study show that lifeguards are not much better than participants who were given a short, non-technical training segment lasting only a couple of minutes based on a verbal description and still-frame image of drowning behavior. In particular, out of 150 critical events, lifeguards only monitored on average 54.0% compared to the trained participants' 49.2%, a difference that failed to reach statistical significance. There was a great amount of variability among the participants—the best naïve participant monitored more critical events (53.33%) than four lifeguards and six trained participants. These results suggest that lifeguards are not performing as well as pool managers and lifeguard trainers would like them to. These results highlight the need for more thorough training programs that cover surveillance and target detection.

Although others have begun to examine lifeguard surveillance to determine whether dangerous events are indeed monitored regularly (see Schwebel, Lindsay, & Simpson, 2007; Schwebel, Simpson, & Lindsay, 2007), this is the first study to examine lifeguard surveillance using an eye-tracker. Using an eye-tracker affords more precision in determining which swimmers are being monitored and which swimmers are not. This information can help guide efforts to improve lifeguard training programs to give lifeguards the tools they need to accurately and efficiently recognize a drowning when it occurs.

Despite the benefit of using an eye-tracker, this study still had limitations. One of the primary limitations was that participants watched video clips on a computer screen, rather than actual swimming activity. Although this ensured that all participants had the exact same visual input (and therefore the exact same potential for success), it prevented the lifeguard from engaging in behaviors that s/he normally engages in when on duty. For instance, a lifeguard who cannot see a patron clearly due to other swimmers or obstacles is free to shift position to get a clearer look. Lifeguards in this study could not. Also, because the stimuli were videos, there was no potential for a rescue. This may have led the participants to be less vigilant than they might otherwise be. Also, the videos did not afford the same visual resolution as standing on the side of a pool or on a beach, and this may have led to the visual difficulty of identifying some behaviors. In the clips drawn from the lake, buoyant floats marked the swimming section of the lake; many participants fixated these floats because they were not clearly identifiable in the resolution of the video.

One other limitation of the current study was the use of short video clips as opposed to longer video clips that afford more knowledge of patron history. A lifeguard who monitors an aquatic zone for 10 minutes has sufficient experience with each patron to evaluate skill and can then prioritize his/her fixations to allow for more evaluations of patrons who are weaker or in situations beyond their ability level. A video of 30 seconds, as used here, may not allow the lifeguard enough time to establish this history and may prevent differences in fixation tendencies to critical versus non-critical events from being observed.

This study is also limited by its small sample. Due to the time-consuming data collection and analysis process, only thirty participants could be run. A small sample, coupled with large variability among participants, could explain why there were few between-group differences on many of the measures. This may limit the generalizability of these results and the conclusions drawn from them.

Despite these limitations, the current study provides a baseline and catalyst for future research examining the extent to which lifeguard surveillance and training methods may be improved upon. The working conditions of the lifeguard—heat, boredom, exhaustion—are already some of the worst conditions for vigilance tasks (see Mackworth, 1950), and the lifeguard community has measures to reduce the effects of these conditions on their guards' surveillance. By requiring lifeguards to rotate positions every 20-30 minutes and to be well-rested when reporting to work, pool managers can ensure that their lifeguards can be as vigilant as possible. The next step is to examine whether there is anything that pool managers or lifeguard trainers can do to improve monitoring of critical events.

It is more than a little troubling that there is not a large difference in critical event monitoring between lifeguards who have gone through a training program and a certification test and had experience monitoring for drowning outside of the laboratory and non-lifeguards who are given only a list of drowning behaviors and a still picture. This suggests that lifeguards may only be extracting this basic list of drowning behaviors from their training and acquire little experience while employed to augment that description. Future research should examine what *lifeguards* view as a critical event compared to what *trainers* view as a critical event, perhaps by asking lifeguards to consciously and explicitly report which patrons need special attention and why. It is possible that a brief training segment on what constitutes a critical event (according to lifeguard trainers) could improve monitoring of these critical events substantially. An intervention developed by Schwebel, Lindsay, and Simpson (2007) focused on reiterating the very real risk of drowning and reviewing the scan patterns taught in training. Schwebel et al. (2007) found that this intervention increased the lifeguards' scanning behavior and decreased their distraction. It is possible that a brief review of why certain patrons should be monitored more closely would be beneficial for lifeguards.

In summary, the current study suggests that lifeguard monitoring is consistent with recommendations, although there is clearly room for improvement. Future research will have to examine the extent to which lifeguard performance can be improved by additional surveillance and target detection training procedures, or intervention programs.

Note

[1]Tom Griffiths (EdD) is the Director of Aquatics and Safety Officer for Athletics at the Pennsylvania State University. Bruce English is the Lifeguard Supervisor at the Pennsylvania State University Natatorium.

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